# THE

# WEALTH OF INDIA

Pl. I

HELIANTHUS ANNUUS — FLOWERING BRANCH

# THE
# WEALTH OF INDIA

A DICTIONARY OF
INDIAN RAW MATERIALS
AND INDUSTRIAL PRODUCTS

## RAW MATERIALS
## VOL. V : H — K



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## INTRODUCTION

This volume marks the completion of the first half of the Wealth of India series on Raw Materials. It contains 380 entries including 370 on plant species, 7 on animals and 3 on minerals. The volume follows in the main the pattern of the previous volumes, except in the case of the article on Insects and Insect Pests, where a departure has been made in literature citations: this has become necessary in view of the more general nature of the article and many of the publications consulted as sources of information cover more than one aspect of the subject. Also a table of contents is provided at the beginning of the article to facilitate reference to individual sections of this lengthy article. Indeed, the suggestion to provide such tables to articles running over several pages in the Dictionary has been made by several contributors, readers and reviewers.

The following contributions from external sources (names given within brackets) have been utilized in preparing the articles: *Iron ores* (Dr. F. G. Percival & Dr. M. V. Wazalwar, Tata Iron & Steel Co., Jamshedpur); *Jade* (The *late* Prof. H. L. Chhibber, Banaras Hindu University); and *Kyanite* (Dr. J. A. Dunn, Geol. Surv. India). The article on *Insects & Insect Pests* has been compiled from contributions by the following: Dr. M. L. Roonwal (Zool. Surv. India, Calcutta), Dr. Y. R. Rao (Retd Entomologist, Bangalore), Dr. K. B. Lal (Plant Protection Adviser, Govt. of India, New Delhi), Dr. I. M. Puri (Malaria Institute, Delhi), Dr. B. C. Basu (School of Trop. Medicine, Calcutta), Dr. M. S. Mani (Zool. Surv. India, Calcutta), Dr. D. S. Rao (Dep. Agric. Mysore, Bangalore) and Dr. P. M. Varma (Virus Entomologist, Agric. College, Poona). The article on *Hevea* has been scrutinized by the Rubber Board, Kottayam, which also supplied the data and illustrations. Many other articles have been scrutinized by specialists and information has been received from a large number of sources. To all these contributors, referees and others, the Chief Editor is greatly indebted. He is also grateful to Prof. A. F. Hill (Botanical Museum, Harvard Univ., Cambridge, Mass. U.S.A.), Dr. D. Chatterjee (Indian Botanic Garden, Calcutta), Dr. S. K. Mukerjee (Central National Herbarium, Bot. Surv. India, Calcutta) and Shri M. B. Raizada (Forest Res. Inst., Dehra Dun) for their advice on plant nomenclature and to the President, Forest Research Institute, Dehra Dun, Director, Indian Agricultural Research Institute, New Delhi and Superintendent, Lal bagh Botanic Gardens, Bangalore, for the supply of illustrations.

The Chief Editor desires to express his gratitude to Prof. M. S. Thacker in particular and to each of the other members of the Editorial Committee for help, guidance and criticism. He is especially indebted to Rev. H. Santapau for valuable assistance in the compilation of botanical articles and to Dr. Baini Prashad for guidance and supervision of the Zoological Unit stationed at Dehra Dun. He also wishes to place on record his grateful appreciation of the unstinted labour and loyal co-operation of his colleagues and staff.

The Chief Editor is keenly conscious of the need for completing the compilation of the remaining volumes expeditiously. The nature of the undertaking, involving as it does an exhaustive scrutiny of all published literature and reports from official and non-official agencies, critical scrutiny of data collected from diverse sources, and refereeing of completed articles by specialists, sets limits to the speeding up of the compilation. Even so, the Editorial Committee has examined the possibilities and taken steps to expedite the further volumes.

Suggestions for improvement will be gratefully received and made use of in subsequent volumes.

New Delhi

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| *Bull. cent. Fd technol. Res. Inst., Mysore* | .. | Bulletin. Central Food and Technological Research Institute. Mysore. |
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| *Bull. Res. Inst., Univ. Travancore* | Bulletin of the Central Research Institute. University of Travancore. Trivandrum. |
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| *Circ. U.S. Dep. Agric.* | Circular. United States Department of Agriculture. Washington, D.C. |
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| *Indian J. Hort.* | .. | Indian Journal of Horticulture. New Delhi. |
| *Indian J. med. Res.* | .. | Indian Journal of Medical Research. Calcutta. |
| *Indian J. Pharm.* | .. | Indian Journal of Pharmacy. Benares. |
| *Indian J. vet. Sci.* | .. | Indian Journal of Veterinary Science and Animal Husbandry. New Delhi. |
| *Indian med. Gaz.* | .. | Indian Medical Gazette. Calcutta. |
| *Indian med. Res. Mem.* | .. | Indian Medical Research Memoirs. Calcutta. |
| *Indian Minerals* | .. | Indian Minerals. Calcutta. |
| *Indian Phytopath.* | .. | Indian Phytopathology. New Delhi. |
| *Indion Pulp Pap.* | .. | Indian Pulp and Paper. Calcutta. |
| *Indian Rubb. Bd Bull.* | .. | Indian Rubber Board Bulletin. Kottayam, Kerala. |
| *Indian Rubb. Bd Serial Pamphl.* | .. | Indian Rubber Board. Serial Pamphlet. Kottayam, Kerala. |
| *Indian Rubb. Bd spec. Leafl.* | .. | Indian Rubber Board. Special Leaflet. Kottayam, Kerala. |
| *Indian Rubb. Bull.* | .. | Indian Rubber Bulletin. Calcutta. |
| *Indian Rubb. Statist.* | .. | Indian Rubber Statistics. Ministry of Food & Agriculture, Govt. of India, New Delhi. |
| *Indian Soap J.* | .. | Indian Soap Journal. Calcutta. |
| *Indian Sug.* | .. | Indian Sugar. Kanpur. |
| *Indian Text. J.* | .. | Indian Textile Journal. Bombay. |
| *Indian Tr. J.* | .. | Indian Trade Journal. Calcutta. |
| *Industr. Engng Chem.* | .. | Industrial and Engineering Chemistry. Easton, Pa. |
| *Industr. Engng Chem. (Anal.)* | .. | Industrial and Engineering Chemistry. Analytical Edition. Easton, Pa. |
| *I. & S. Bull.* | .. | I. & S. Bulletin. Ministry of Industry & Supply, Govt. of India. New Delhi. |
| *Japan Sci. Rev., Biol. Sci.* | .. | Japan Science Review. Biological Sciences. Tokyo. |
| *J. agric. Fd Chem.* | .. | Journal of Agricultural and Food Chemistry. Easton, Pa. |
| *J. Amer. chem. Soc.* | .. | Journal of the American Chemical Society. Easton, Pa. |
| *J. Amer. Oil Chem. Soc.* | .. | Journal of the American Oil Chemists' Society. Chicago. |
| *J. Arnold Arbor.* | .. | Journal of the Arnold Arboretum. Lancaster, Pa. |
| *J. Ass. off. agric. Chem., Wash* | .. | Journal of the Association of Official Agricultural Chemists. Washington, D.C. |
| *J. biol. Chem.* | .. | Journal of Biological Chemistry. Baltimore, Md. |
| *J. Bombay nat. Hist. Soc.* | .. | Journal of the Bombay Natural History Society. Bombay. |
| *J. cent. Bur. Anim. Husb. India* | .. | Journal of the Central Bureau for Animal Husbandry and Dairying in India. Calcutta. |
| *J. chem. Soc.* | .. | Journal of the Chemical Society. London. |
| *J. Coun. sci. industr. Res. Aust.* | . | Journal of the Council for Scientific and Industrial Research, Australia. Melbourne |
| *J. Dep. Agric. W. Aust.* | . | Journal of the Department of Agriculture for Western Australia. Perth. |
| *J. econ. Ent.* | . | Journal of Economic Entomology. Geneva, N.Y. |
| *J. Genet.* | . | Journal of Genetics. Cambridge. |
| *J. Gujarat Res. Soc.* | . | Journal of the Gujarat Research Society. Bombay. |
| *J. Hered.* | . | Journal of Heredity. Washington, D.C. |
| *J. Indian bot. Soc.* | . | Journal of the Indian Botanical Society. Madras. |
| *J. Indian chem. Soc.* | . | Journal of the Indian Chemical Society. Calcutta. |
| *J. Indian chem. Soc. industr. Edn* | . | Journal of the Indian Chemical Society. Industrial and News Edition. Calcutta. |
| *J. Indian Inst. Sci.* | .. | Journal of the Indian Institute of Science. Bangalore. |
| *J. industr. Engng Chem.* | . | Journal of Industrial and Engineering Chemistry. Easton, Pa. |
| *J. Instn Chem. India* | . | Journal and Proceedings of the Institution of Chemists, India. Calcutta. |

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| *J. Jap. Bot.* | .. | Journal of Japanese Botany. Tokyo. |
| *J. Malar. Inst. India* | .. | Journal of the Malaria Institute of India. Calcutta. |
| *J. Mysore hort. Soc.* | .. | Journal of the Mysore Horticultural Society. Bangalore. |
| *J. N.Y. bot. Gdn* | .. | Journal of the New York Botanical Garden. New York. |
| *J. Pharm., Lond.* | .. | Journal of Pharmacy and Pharmacology. London. |
| *J. R. hort. Soc.* | .. | Journal of the Royal Horticultural Society. London. |
| *J. Sci. Fd Agric.* | .. | Journal of the Science of Food and Agriculture. London. |
| *J. sci. industr. Res.* | .. | Journal of Scientific and Industrial Research. New Delhi. |
| *J. sci. Res. Indonesia* | .. | Journal for Scientific Research in Indonesia. Djakarta. |
| *J. Soc. chem. Ind., Lond.* | .. | Journal of the Society of Chemical Industry. London. |
| *J. Text. Inst.* | .. | Journal of the Textile Institute. Manchester. |
| *J. Univ. Bombay* | .. | Journal of the University of Bombay. Bombay. |
| *J. zool. Soc. India* | .. | Journal of the Zoological Society of India. Calcutta. |
| *Jt Publ. imp. agric. Bur.* | .. | Joint Publications. Imperial (Commonwealth) Agricultural Bureau. Aberystwyth |
| *Jute Bull.* | .. | Jute Bulletin. Calcutta. |
| *Kew Bull.* | .. | Kew Bulletin. Royal Botanic Gardens, Kew. |
| *Kew Bull. Addl Ser.* | .. | Kew Bulletin. Additional Series. Royal Botanic Gardens, Kew. |
| *Leafl. Dep. Agric. Assam* | .. | Leaflet. Department of Agriculture, Assam. Shillong. |
| *Leafl. U.S. Dep. Agric.* | .. | Leaflet. United States Department of Agriculture. Washington, D.C. |
| *Lloydia* | .. | Lloydia. Menasha, Wisconsin. |
| *Madras agric. J.* | .. | Madras Agricultural Journal. Coimbatore. |
| *Madras For. Coll. Mag.* | .. | Madras Forest College Magazine. Coimbatore. |
| *Malay. agric. J.* | .. | Malayan Agricultural Journal. Kuala Lumpur. |
| *Melliand Textilber.* | .. | Melliand Textilberichte. Mannheim. |
| *Mem. Dep. Agric. India, Bot.* | .. | Memoirs of the Department of Agriculture in India. Botanical series. Pusa. |
| *Mem. Dep. Agric. India, Chem.* | .. | Memoirs of the Department of Agriculture in India. Chemical Series. Pusa. |
| *Mem. Dep. Agric. Madras* | .. | Memoirs of the Department of Agriculture, Madras. Madras. |
| *Mem. ent. Soc. India* | .. | Memoirs of the Entomological Society of India. New Delhi. |
| *Mem. geol. Surv. India* | .. | Memoirs of the Geological Survey of India. Calcutta. |
| *Mem. Tocklai exp. Sta.* | .. | Memoirs of the Tocklai Experimental Station. Assam. |
| *Miner. Yearb., Wash.* | .. | Minerals Yearbook. Washington, D.C. |
| *Misc. Bull. Indian Coun. agric. Res.* | .. | Miscellaneous Bulletin. Indian Council of Agricultural Research. New Delhi. |
| *Mysore agric. J.* | .. | Mysore Agricultural Journal. Bangalore. |
| *Nature, Lond.* | .. | Nature. London. |
| *Naturwissenschaften* | .. | Naturwissenschaften. Berlin. |
| *N.Z. J. Sci. Tech.* | .. | New Zealand Journal of Science and Technology. Wellington. |
| *Nutr. Abstr. Rev.* | .. | Nutrition Abstracts and Reviews. Aberdeen. |
| *Oilseeds Ser. Indian Oilseeds Comm.* | .. | Oilseeds Series. Indian Central Oilseeds Committee. Hyderabad. |
| *Pacif. Sci.* | .. | Pacific Science. Honolulu. |
| *Pakist. J. Sci.* | .. | Pakistan Journal of Science. Lahore. |
| *Pap. Mich. Acad. Sci.* | .. | Papers from the Michigan Academy of Science, Arts and Letters. Ann Arbor, Mich. |
| *Perfum. essent. Oil Rec.* | .. | Perfumery and Essential Oil Record. London. |
| *Pharm. J.* | .. | Pharmaceutical Journal and Pharmacist. London. |
| *Philipp. agric. Rev.* | .. | Philippine Agricultural Review. Manila. |
| *Philipp. J. Sci.* | .. | Philippine Journal of Science. Manila. |
| *Plant Breed. Abstr.* | .. | Plant Breeding Abstracts. Cambridge. |
| *Plant. Chron.* | .. | Planters' Chronicle. Coimbatore. |
| *Plant Physiol.* | .. | Plant Physiology. Lancaster, Pa. |
| *Plant Prot. Bull., N. Delhi* | .. | Plant Protection Bulletin. New Delhi. |
| *Poona agric. Coll. Mag.* | .. | Poona Agricultural College Magazine. Poona. |
| *Proc. Amer. Soc. hort. Sci.* | .. | Proceedings. American Society for Horticultural Science. College Park, Md. |
| *Proc. Bihar Acad. agric. Sci.* | .. | Proceedings of the Bihar Academy of Agricultural Science. Sabour, Bihar. |
| *Proc. ent. Soc. Wash.* | .. | Proceedings of the Entomological Society of Washington. Washington, D.C. |
| *Proc. Indian Acad. Sci.* | .. | Proceedings of the Indian Academy of Sciences. Bangalore. |
| *Proc. Indian Sci. Congr.* | .. | Proceedings of the Indian Science Congress. Calcutta. |
| *Proc. nat. Acad. Sci. India* | .. | Proceedings of the National Academy of Sciences, India. Allahabad |

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| *Proc. nat. Inst. Sci. India* | .. | Proceedings of the National Institute of Sciences of India. Calcutta |
| *Proc. Pakist. Sci. Conf.* | .. | Proceedings of the Pakistan Science Conference. Lahore. |
| *Proc. Rajasthan Acad. Sci.* | .. | Proceedings of the Rajasthan Academy of Sciences. Pilani. |
| *Proc. Zool. Soc. Beng.* | .. | Proceedings of the Zoological Society of Bengal. Calcutta. |
| *Psyche, Camb., Mass.* | .. | Psyche, a Journal of Entomology. Cambridge, Mass. |
| *Punjab agric. Coll. Mag.* | .. | Punjab Agricultural College Magazine. Lyallpur. |
| *Punjab Fmr* | .. | Punjab Farmer. Simla. |
| *Punjab Fr. J.* | .. | Punjab Fruit Journal. Lahore. |
| *Quart. J. geol. Soc. India* | .. | Quarterly Journal of the Geological, Mining and Metallurgical Society of India. Calcutta. |
| *Rec. bot. Surv. India* | .. | Records of the Botanical Survey of India. Calcutta. |
| *Rec. geol. Surv. India* | .. | Records of the Geological Survey of India. Calcutta. |
| *Rep. Bose Inst.* | .. | Report of the Bose Institute. Calcutta. |
| *Rep. Dep. Res. Univ. Travancore* | .. | Report. Department of Research. University of Travancore. Trivandrum. |
| *Rep. ess. Oils Schimmel* | .. | Annual Report on Essential Oils, Aromatic Chemicals and Related Materials, Schimmel & Co. New York. |
| *Rep. Indian Coun. agric. Res.* | .. | Report. Indian Council of Agricultural Research. Calcutta. |
| *Rep. Indian Jute Comm.* | .. | Annual Report. Indian Central Jute Committee. Calcutta. |
| *Rep. Jute agric. Res. Inst., Indian Jute Comm.* | | Report of the Jute Agricultural Research Institute. Indian Central Jute Committee. Calcutta. |
| *Rep. Rubb. Bd* | .. | Report. Rubber Board. Kottayam, Kerala. |
| *Rhod. agric. J.* | .. | Rhodesia Agricultural Journal. Salisbury. |
| *Rubb. Bd Bull.* | .. | Rubber Board Bulletin. Kottayam, Kerala. |
| *Rubb. India* | .. | Rubber India. Bombay. |
| *Rubber in India* | .. | Rubber in India. Ministry of Food & Agriculture. Govt. of India. New Delhi. |
| *Rubb. Statist. Bull.* | .. | Rubber Statistical Bulletin. International Rubber Study Group. London. |
| *S. Afr. J. Sci.* | .. | South African Journal of Sciences. Cape Town |
| *Science* | .. | Science. New York. |
| *Sci. & Cult.* | .. | Science and Culture. Calcutta. |
| *Sci. Agric* | .. | Scientific Agriculture. Ottawa. |
| *Sci. Mon., N.Y.* | .. | Scientific Monthly. New York. |
| *Sci. Monogr. Coun. agric. Res. India* | .. | Scientific Monograph. Indian (Imperial) Council of Agricultural Research, India. Calcutta. |
| *Sci. News Lett., Wash.* | .. | Science News Letter. Washington, D.C. |
| *Sci. Progr.* | .. | Science Progress. Washington, D.C. |
| *Sci. Rep. agric. Res. Inst. N. Delhi* | .. | Scientific Reports of the Indian (Imperial) Agricultural Research Institute, New Delhi. |
| *Sci. Ser. Dep. Agric., Malaya* | .. | Scientific Series. Department of Agriculture. Federation of Malaya. Johore Bahru. |
| *Seas. Crop Rep.* | .. | Season and Crop Report. |
| *Stylops* | .. | Stylops. A Journal of Taxonomic Entomology. London. |
| *Sugar* | .. | Sugar. Baltimore, Md. |
| *Tanner* | .. | Tanner. Bombay. |
| *Tea Encyclopaedia* | .. | Tea Encyclopaedia. Indian Tea Association. Scientific Department, Tocklai. Assam. |
| *Tech. Bull. Hawaii agric. Exp. Sta.* | .. | Technical Bulletin. Hawaii Agricultural Experiment Station. Honolulu. |
| *Tech. Bull. U.S. Dep. Agric.* | .. | Technical Bulletin. U.S. Department of Agriculture. Washington, D.C. |
| *Tech. Bull. Va agric. Exp. Sta.* | .. | Technical Bulletin. Virginia Agricultural Experiment Station. Blacksburg. |
| *Trans. Min. geol. Inst. India.* | .. | Transactions of the Mining and Geological (and Metallurgical) Institute of India. Calcutta. |
| *Trans. nat. Inst. Sci. India.* | .. | Transactions of the National Institute of Sciences of India. Calcutta. |
| *Trans. R. ent. Soc. Lond.* | .. | Transactions of the Royal Entomological Society of London. London. |
| *Trop. Agriculture. Trin.* | .. | Tropical Agriculture. Trinidad. |
| *Trop. Agriculturist* | .. | Tropical Agriculturist and Magazine of the Ceylon Agricultural Society. Peradeniya. |
| *Trop. Woods* | .. | Tropical Woods. New Haven, Conn. |
| *U.S. Dep. Agric. Bibliogr. Bull.* | .. | United States Department of Agriculture. Bibliographical Bulletin. Washington, D.C. |
| *World Crops* | .. | World Crops. London. |
| *Yearb. Agric. U.S. Dep. Agric.* | .. | Yearbook of Agriculture. United States Department of Agriculture. Washington, D.C. |
| *Z. angew. Ent.* | .. | Zeitschrift fur angewandte Entomologie. Berlin. |
| *Zuchter* | .. | Zuchter. Zeitschrift fur theoretische und angewandte Genetik. Berlin. |

# RAW MATERIALS
# VOL. V : H — K

# H

**HABENARIA** Willd. (*Orchidaceae*)

A large genus of orchids found in tropical and temperate parts of the world. About 8 species are reported from India, of which two are of minor economic importance.

**H. commelinifolia** Wall. ex Lindl.

Fl. Br. Ind., VI, 143.

A ground orchid, 2–3 ft. high, with white, inodorous flowers, 0.5–0.75 inch in diameter, found nearly throughout India, from Punjab and Kumaon eastwards to Bihar, Chota Nagpur and Orissa and southwards in Central, West and South India. It occurs in open sandy soils, paddy fields and grasslands. The tubers of the plant, which are elliptic or cylindrical, furnish a salep (Mooney, 207 ; Kirt. & Basu, IV, 2415).

**H. susannae** (Linn.) R. Br. = *Platanthera susannae* (Linn.) Lindl.

Fl. Br. Ind., VI, 137.

*Photo : H. Santapau*

FIG. 1. HABENARIA SUSANNAE—FLOWERING BRANCH

CHOTA NAGPUR—*Hukakanda* ; BOMBAY—*Waghchoora*.

A robust, ornamental, ground orchid, with underground tubers, 3–4 in. long, found nearly throughout India, up to an elevation of 4,000–6,000 ft. It bears white, fragrant flowers, 3–4 inches in diameter and is considered by orchid fanciers as the largest and the most showy among *Habenaria* spp. It can be cultivated from tubers, if care is taken to rest them after the leafy stems have died (Bailey, 1947, II, 1424 ; Fl. Malaya, I, 81).

Though fairly frequent in western ghats and other areas in India, the orchid is reported to be rapidly disappearing due to the indiscriminate digging up for its edible tubers. The tubers are much sought after by jungle tribes and by wild pigs. The tubers are also used as a cure for blebs or bullae, specially those occurring on the palm of the hand (Mooney, 206 ; Collett, 501 ; Santapau, *Rec. bot. Surv. India*, 1953, **16,** 305 ; Dixon, *J. Bombay nat. Hist. Soc.*, 1896, **10,** 328).

**HACKELOCHLOA** Kuntze (*Gramineae*)

D.E.P., III, 424 ; V, 164 ; Fl. Br. Ind., VII, 159 ; Blatter & McCann, 32, Pl. 22.

A genus of annual grasses distributed in the tropical countries of the world. Two species occur in India of which *H. granularis* (Linn.) Kuntze syn. *Manisuris granularis* Linn. f. (SANS.—*Palanggini* ; HINDI—*Trinpali, kangni* ; GUJ.—*Kasiunghas* ; TEL.—*Kurujedanai gaddi, guru singu gaddi* ; KAN.—*Kadu sanna harka hullu*) is of some importance. It is an annual grass, with culms 1–3 ft. high, found throughout the warmer parts of India, in open grasslands and cultivated fields. It is considered to be a moderately good fodder in all stages of growth ; it is also suitable for hay. Analysis of the grass gave the following values (dry basis): protein, 6.35 ; fat, 0.92 ; carbohydrates, 45.55 ; crude fibre, 32.86 ; and ash, 14.32% (Burkill, II, 1422 ; Fl. Assam, V, 442 ; Fl. Madras, 1758 ; Dalziel, 529 ; Walandouw, *J. sci. Res. Indonesia*, 1952, **1,** 201).

**HAEMANTHUS** Linn. (*Amaryllidaceae*)

Chittenden, II, 946 ; Macmillan, 133, Fig.

A genus of bulbous herbs native mostly of Africa. A few species are cultivated in Indian gardens.

Commonly known as BLOOD LILIES, *Haemanthus* species are propagated by offsets which are produced freely. A well-drained light or sandy, but rich soil is suitable. For pot culture, two parts of light soil and one part of well-decayed farmyard manure are needed; a weak liquid manure is desirable during early stages. The plants flower better if under-potted, when it is unnecessary to shift them every year [Desai, *Indian Fmg, N.S.*, 1956–57, **6**(5), 24].

*H. multiflorus* Martyn syn. *H. kalbreyeri* Baker (PAINTER'S BRUSH LILY) is the best known species of the genus grown in India. Bulbs globose, *c.* 3 in. thick; leaves several, oblong, *c.* 12 in. long, stalked; flowers scarlet, borne in a globular head at the end of a red-spotted scape (1–1.5 ft. long) with long, projecting stamens, giving the head an attractive pincushion or brush-like appearance (Gopalaswamiengar, 492).

*H. albomaculatus* Baker and *H. albiflos* Jacq., white-flowered species, though not so common, are attractive garden plants (Firminger, 333–34).

The bulbs of many *Haemanthus* spp. contain toxic alkaloids. *H. multiflorus* is used as a fish poison in Africa; it is also reported to be poisonous to pigs. Extracts of the bulb are reported to be used as topical treatment for ulcers and wounds. The bulb contains an alkaloid, haemanthine ($C_{18}H_{23}O_6N$). Fresh bulbs of *H. albiflos* contain 0.18% of amorphous and 0.077% of crystalline alkaloids. Lycorenine and tazettine have been identified: the latter has slight hypotensive activity. Fresh bulbs of *H. albomaculatus* contain 0.33% of amorphous alkaloids (Dalziel, 487; Githens, 91; Wildman & Kaufmann, *J. Amer. chem. Soc.*, 1955, **77**, 1248).

## HAEMATOCARPUS Miers (*Menispermaceae*)

Fl. Br. Ind., I, 106.

A genus of about three species occurring in the Himalayas, of which *H. thomsonii* Miers (ASSAM—*Inramjidukha*), a large woody climber with leaves 3–6 in. long and 1.5–2.5 in. wide, is found in Sikkim and Khasi hills, up to an altitude of 3,000–4,000 ft. Fruits smooth, sub-oblique, drupacious, 1.5–2 in. long and 1–1.3 in. wide, borne solitarily or in bunches of 2 to 4, on stout woody racemes up to 15 in. long. Fruits are borne in April–May and ripe fruits which are juicy and blood-red in colour are eaten by the local people (Fl. Assam, I, 58).

## HAEMATOXYLON Linn. (*Leguminosae*)

A small genus of trees distributed in Central America and Africa. One species is cultivated in India.

**H. campechianum** Linn. LOGWOOD, CAMPEACHY TREE

D.E.P., IV, 198; Benthall, 185.

HINDI—*Patang;* BENG.—*Bokkan;* TEL.—*Gabbi;* KAN.—*Partanga.*

A small, rarely medium-sized, thorny tree with fluted or contorted trunk, often cultivated in Indian gardens for its delicate foliage and fragrant flowers; it is sometimes grown as a hedge plant. Bark dark brown, peeling in small flakes; leaves paripinnate: leaflets obovate or obcordate; flowers small, yellow, in axillary racemes; pods flattened, lanceolate, usually 2-seeded. The tree is propagated by seed and by cuttings.

The heartwood of *H. campechianum* constitutes the Logwood of commerce, which yields a well-known dye, or rather a series of dyes of the darker tints, such as grey, violet, blue and even black. The colouring principle of logwood is haematoxylin, $C_{16}H_{14}O_6.3H_2O$ (present to the extent of 10%) which on mild oxidation gives haematein $C_{16}H_{12}O_6$, a dark violet crystalline body with a green metallic lustre. Chipped logwood is subjected to the 'ageing' process to facilitate haematein formation. Logwood Extract prepared from unaged wood by aqueous exhaustion and concentration of extract in vacuum pans, and Haematein Paste, a treacly extract containing in suspension, minute crystals of haematein, are articles of commerce. Logwood and its extracts are used for the dyeing of blacks on wool and silk and, to a limited extent, on cotton chiefly in conjunction with iron chromium mordants; they can also be used for dyeing rayon and nylon. The tinctorial strength, and the evenness and the pleasing nature of dyeings are important considerations in their use; they do not cause any tendering of fibre. Logwood is also used for dyeing leather, fur, jute, and bone and in the manufacture of inks. Haematoxylin is used as a histological stain, particularly for cell nuclei. Haematein in alcohol solution is used as an indicator for alkaloid titration (Thorpe, VII, 378–81; Trease, 423; U.S.D., 1955, 1710).

In addition to haematoxylin, the heartwood contains tannin, resin, quercetin, traces of volatile oil, oxalic acid, and acetic acid (Wehmer, I, 511).

Logwood is prescribed in the form of decoction and liquid extract as an astringent and tonic. Its medicinal value depends on the presence of tannin. It is useful in diarrhoea, dysentery, atonic dyspepsia and leucorrhoea. An ointment prepared from the

wood is said to be useful in cancer and hospital gangrene. Chipped logwood of commerce is unfit for medicinal use (Kirt. & Basu, II, 886 ; U.S.D., loc. cit.).

The sapwood is white or yellowish ; the heartwood, which has an agreeable odour and sweet astringent taste, acquires a reddish bright colour on exposure. The heartwood is interlocked-grained and medium-to fine-textured, heavy (sp. gr., 1.057 ; wt., 65 lb./cu. ft.), very hard and strong but brittle. It is difficult to work by hand, but can be finished to a smooth surface and takes a high polish. The wood is durable in contact with the ground and in exposed positions. Its use as timber, however, is largely prevented by the irregular shape of the stems, though it is occasionally used for marquetry (Titmuss, 77 : Record & Hess, 278).

The leaves contain quercetin, tannin, ellagic acid and myricetin ; ethyl gallate, a mycobacteria-specific antibiotic, has also been isolated. The nectar from the flowers is sought by bees and yields honey of high quality (Wehmer, loc. cit. ; *Biol. Abstr.*, 1953, **27**, 2876 ; Burkill, I, 1125).

**HAGENIA** J. F. Gmelin (*Rosaceae*)

D.E.P., I, 534 ; Bentley & Trimen, II, 102.

A monotypic genus represented by *H. abyssinica* (Bruce) J. F. Gmelin syn. *Brayera anthelmintica* Kunth ; *B. abyssinica* Moq., indigenous to north-east Africa and the source of the anthelmintic drug, known as Brayera, Kousso or Cusso, reported to be imported into Bombay.

*H. abyssinica* is a monoecious tree, 20–40 ft. high with large imparipinnate leaves, paniculate inflorescences and achenial fruits. The panicles of female flowers form the drug of commerce. They are collected in full bloom, dried in the sun, and compressed into flattened bundles or cylindrical rolls (10-20 in. long × 2 in. diam.). Broken pieces of panicles are marketed as Loose Kousso and male flowers and fragments of leaves are often present in it.

Kousso has a characteristic dull red colour with a disagreeable, bitter, acrid taste. It is usually administered in the form of an infusion, especially for the expulsion of tapeworm ; it is ineffective against hookworm, roundworm and whipworm. It is irritant to the mucous membrane and in large doses produces nausea, vomiting and colic. The plant is reported to possess marked necrotising effect on sarcoma tumour (B.P.C., 1949, 282 : Youngken, 418 : U.S.D., 1955, 1607 ; Caius & Mhaskar, *Indian J. med. Res.*, 1921, **9**, 198 ; *Biol. Abstr.*, 1953, **27**, 2105).

The active constituent of kousso is kosotoxin, an amorphous, yellowish substance allied to filicic acid and rottlerin. Other constituents of the drug are protokosin and kosidin, as well as tannin and resin (Wehmer, I, 457 ; Wallis, 156 ; B.P.C., loc. cit. ; *Biol. Abstr.*, 1953, **27**, 1309).

**Hair Palm** — *see* **Chamaerops**

**Hairy Willow Weed** — *see* **Epilobium**

**Hai Tung Pi** — *see* **Erythrina**

**HAKEA** Schrad. (*Proteaceae*)

Bailey, 1949, 344.

A genus of evergreen shrubs and small trees native of Australia. A few species are cultivated in Indian gardens.

*H. laurina* R. Br. is a tall tree-like shrub with elliptic-lanceolate leaves and strikingly handsome crimson flowers in globular clusters, reported to be grown in Nilgiris. It is likely to find favour in flower trade as cut flowering twigs keep for a long time in water. The leaves contain quebrachite, sucrose and two glucosides, one of which has been identified as arbutin (Lushington, IIA, 612 : Wehmer, I, 255 ; *Chem. Abstr.*, 1919, **13**, 969).

*H. saligna* Knight is an ornamental shrub, up to 12 ft. high, with oblong-lanceolate leaves, small dense clusters of white fragrant flowers and rough woody capsules. It is reported to be cultivated as a hedge plant in Darjeeling and Nilgiris. The bark of the plant is rich in tannins (20%) ; flowers are cyanogenetic (Biswas, *Rec. bot. Surv. India*, 1940, **5**, 419 ; Lushington, IIA, 612 ; Howes, 1953, 278 ; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 135).

*H. sericea* Schrad. syn. *H. acicularis* Knight is a conifer-like plant with needle-like leaves and axillary clusters of white or pinkish flowers, reported to be cultivated in Shillong and Nilgiris. It yields a gum which, when fresh, is soft and completely soluble in water, but turns into a hard, horny mass on drying. On hydrolysis, the gum yields *l*-arabinose (19%), *d*-xylose (8%), *d*-galactose (58%), *d*-mannose (7%) and *d*-glucuronic acid (8%) (Fl. Assam, IV, 107 ; Chatterjee, *Sci. & Cult.*, 1949–50, **15**, 156 ; Stephen, *J. chem. Soc.*, 1956, 4487).

**HALICORES** (Class, *Mammalia* ; Order, *Sirenia* ; Family, *Dugongidae*)

D.E.P., III, 197 ; VI(4), 304 ; Fn. Br. Ind., Mammalia, 594 ; Reese, 314 ; Sterndale, 133 ; Prater, *J. Bombay nat. Hist. Soc.*, 1928, **33**, 84, Pl.

*Sirenia*, the Sea Cows, belong to a small decadent order of sluggish, aquatic, vegetarian mammals, very superficially connected with whales and allied forms. They have probably evolved from a primitive swamp-dwelling common ancestor, which, on the one hand, gave rise to forms adapted to aquatic life, the modern sea cows, and on the other, to terrestrial forms, the elephants. There are two living genera of sea cows, the *Dugong* (Halicores, Dugongs) and *Manatus* (Manatees) : only the former is represented in Indian waters. Halicores are known as sea cows because of the cow-like shape of their muzzle and the habit of browsing on underwater vegetation. Manatees belong to a closely allied genus resembling halicores in size and form, but differing from them in certain structural features ; halicores are more marine in habit than manatees (Pycraft, 807 ; Regan, 729).

The Indian dugong, *Dugong dugong* (Müller), (TAM. -*Kadalpudru*), *c.* 9 ft. 6 in. long, is a coastal animal avoiding both open sea and freshwater. It lives in the warmer parts of the Indian Ocean, ranging from East Africa to Australia, about 15° on either side of the equator. It has been recorded from the salt water inlets of South Malabar, Konkan coast and, occasionally, round Dhanushkodi, Rameswaram, Pamban, Krusadi and Koipadu Islands between November and January. On the east coast, it is found in small numbers on the shores of the Gulf of Mannar and neighbouring islands and in larger numbers on the shores of Andaman Islands. The numbers are progressively dwindling (Ellerman & Morrison-Scott, 337).

The dugong is a sluggish animal, 4 6 cwt. in weight, with massive plump body and heavy bones. Skin thick, tough, somewhat oily and sparsely haired ; colour slaty grey : body separated from head by a short and indistinct neck ; nostrils with valves for closing them located on the top of the head : posterior limbs absent, while the anterior pair is modified into paddle-shaped flippers for swimming : teats in female one pair under flippers ; tusks present only in male : eyes small ; external ear and dorsal fin absent ; tail flattened and expanded into a broad tail fin. The bones, unlike those of whales, are heavy and enable the animal to sink to the bottom where it feeds on seaweeds and aquatic plants. The animal comes up to the surface, at intervals, to breathe. It never leaves the water, but occasionally visits bays, estuaries and lagoons not far away from the sea. It is quite harmless and is easily killed by spearing (Thomson, 928–29 ; Pycraft, 806).

The dugong uses flippers not only to direct the food to the mouth, but also to paddle and balance itself in water and in the case of female, for holding the young to the breast. The animal gives birth to one pup at a time, the gestation period being one year (Baker, M. & Bridges, W., 96).

The flesh of dugong is delicious and is highly esteemed by Muslims in coastal areas of India and Ceylon. Roasted flesh is indistinguishable from good, tough, beef steak. It has good keeping qualities and remains eatable up to 3 days even in hot climates ; salted and dried meat keeps longer.

Dugong fat is used like butter and as a cooking medium. Dugong fat is extracted from the tissues by boiling with water, when it floats to the top and is skimmed off. A yield of 6-14 gal. per animal is obtained. The fat is free from any unpleasant odour and the refined product is clear and limpid. The following constants have been recorded for dugong fat from Australia : sp. gr.$^{15°}_{15°}$, 0.9242 ; sp. gr.$^{100°}_{15°}$, 0.8622 ; $n^{40°}_{D}$, 1.458 ; $[\alpha]^{40°}$, $-0.12°$ ; acid val., 0.3 ; sap. val., 204.7 ; iod. val. (Hubl), 52.3 ; and unsapon. matter, 0.2% ; solid. pt of fatty acids, 34.6° (*Chem. Abstr.*, 1926, **20,** 833).

Dugong fat is used as a substitute for cod liver oil, and several medicinal properties have been ascribed to it. It is reported to possess laxative properties. It is used for dysentery in Ceylon. The fat extracted from the head is used as a calmative in head- and ear-aches. It is used also in skin affections and leprosy. The bone, particularly the skull bone, is used in powdered form in applications for ulcers. The powder made out of the last rib is reported to be used in lung complaints. The hide of sea cow is tanned into leather and employed for roofing tabernacles in Israel and for making sandals for women. A decolourising char coal is prepared from the bones. Cigarette holders and rosaries are made from the tusks.

**Halite** — *see* **Salt**

**HALOPHILA** Thouars (*Hydrocharitaceae*)
Fl. Br. Ind., V, 663.

A small genus of submerged marine herbs, found on the coasts of Africa, India, Australia and the Pacific Islands. Two species are reported from India.

*H. ovalis* Hook. f. syn. *H. ovata* Gaudich. (Fl. Br. Ind. in part), a small herb with creeping stems, rooting at nodes and bearing membranous leaves, 2–2½ in. long, occurs along the coast and in backwaters of Chilka lake (Orissa), S. India and Ceylon. *H. ovalis* is often washed ashore along with other seaweeds and

is used occasionally as manure in coconut and other plantations. On analysis, a mixture of the weeds, of which *H. ovalis* formed the major component, showed the following composition—*dry material washed ashore :* N, 0.7 ; $K_2O$, 0.46 ; pentosans, 3.95 ; lignin, 9.14 ; ash, 53.72 ; insoluble ash, 42.05 ; and NaCl, 8.81% ; $P_2O_5$, traces ; pentosan/lignin ratio, 0.39. Compared to other seaweeds, this material is poor in manurial value ; further, it is resistant to decomposition in the soil, due to its low pentosan/lignin ratio (Salgado & Chinnarasa, *Trop. Agriculturist*, 1936, **87,** 385).

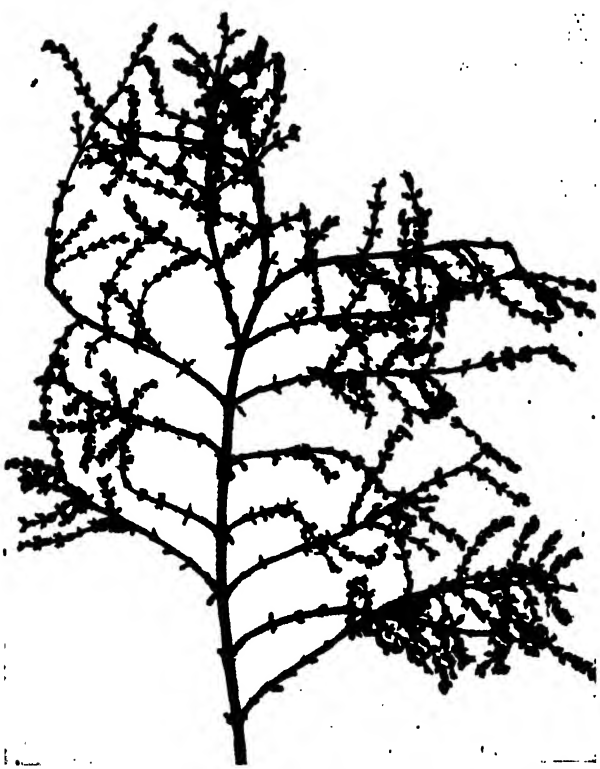
**HALOXYLON** Bunge (*Chenopodiaceae*)

D.E.P., IV, 199 ; C.P., 113 ; Fl. Br. Ind., V, 15.

A genus of shrubs or small trees with articulate branches, distributed chiefly from the Mediterranean region to Central and South Asia. Three species occur in India.

*H. recurvum* Bunge is a tall straggling bush with small, fleshy ovate-subulate leaves and strict spikes of axillary flowers, found in Punjab, Rajasthan and Coimbatore. The plant has been used as a source of crude sodium carbonate—*Barilla* or *Sajji-khar*, formerly used for making soap and glass. For this purpose, the plants are cut at the time of flowering, left to dry for about a fortnight, piled in a heap and burned ; the sap which collects in a hole, prepared in the ground for receiving it, solidifies into a hard mass of *sajji-khar*. The ashes of the plant are used by dhobies for washing clothes ; they are also given for internal ulcers. Though stated to be poisonous, the plant is used as fodder for camels ; it is cut and sold for this purpose (Blatter & Hallberg, *J. Bombay nat. Hist. Soc.*, 1918–21, **26,** 968 ; Parker, 418-19 ; Kirt. & Basu, III, 2089).

*H. multiflorum* Bunge and *H. salicornicum* Bunge are low, erect, almost leafless shrubs found in parts of Punjab and Rajasthan. They are used as adulterants or substitutes for *H. recurvum*.



*Blatter Herbarium, Bombay*

FIG. 2. HALOXYLON RECURVUM—FRUITING BRANCH

**Hamadryad** — *see* **Snakes**

**HAMELIA** Jacq. (*Rubiaceae*)

Bailey, 1947, II, 1431.

A genus of woody shrubs indigenous to tropical and subtropical America. One species, *H. patens* Jacq. (syn. *H. erecta* Jacq.), has been introduced into India and is widely grown as an ornamental plant in gardens. It is a large, evergreen shrub, with dense attractive foliage of greenish bronze leaves. Flowers orange-red, tubular, borne in profusion during hot and rainy seasons ; berries blood-red, edible. The plant

FIG. 3. HAMELIA PATENS—FLOWERING BRANCH

is easily propagated by cuttings or by seeds. It stands pruning well and can be trimmed to any shape and makes a good ornamental hedge (Firminger, 29; Gopalaswamiengar, 270; Bor & Raizada, 97; Neal, 699).

The red flowers yield a mixture of two pentose glycosides, probably malvidin and petunidin, the former being the major component. A syrup made of the berries is said to be useful in dysentery. The plant is reported to be poisonous (Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B,** 211; Williams & Williams, 183; Burkill, I, 1126).

## HAMILTONIA Roxb. (*Rubiaceae*)

A small genus of shrubs found in the Indo-Malayan region and China. One species occurs in India.

**H. suaveolens** Roxb.

D.E.P., IV, 200; Fl. Br. Ind., III, 197; Bor & Raizada, Pl. 34 & 35.

TEL.—*Kondamuritidi;* ORIYA—*Janamirgiri, pitondi.*

PUNJAB—*Kanera, muskei, kantalu, tulenni;* KUMAON—*Padera;* NEPAL—*Bain champa;* BIHAR—*Meda punp, jataini ba;* M.P.—*Mahabal;* BOMBAY—*Gidesa, gidasawa.*

*F.R.I., Dehra Dun. Photo: M. B. Raizada*

FIG. 4. HAMILTONIA SUAVEOLENS—FLOWERING BRANCH

A shrub up to 12 ft. high, found almost throughout India, ascending up to an altitude of 6,500 ft.; the plant is also cultivated in gardens. Bark shining grey, peeling off in papery flakes; leaves large, elliptic-lanceolate, variable, giving a foetid odour when crushed; flowers blue or white, fragrant, in terminal branched panicles; capsules ellipsoid.

The plant is used by Mundas of Ranchi district (Bihar), along with mustard oil, as an application for wounds; the bark is ground and rubbed on the body in puerperal fever. The root is given in diarrhoea. An infusion of the root is given in courbature. The wood is dark grey, soft and porous; it is reported to be used for making gunpowder charcoal. The leaves are eaten by buffaloes (Bressers, 73; Haines, IV, 442; Kirt. & Basu, II, 1300).

**Hangul (Hangal)** — *see* **Deer**

## HAPLANTHUS Nees (*Acanthaceae*)

Fl. Br. Ind., IV, 506.

A genus of herbs distributed in the Indo-Malayan region. Three species occur in India.

*H. verticillatus* (Roxb.) Nees (HINDI—*Kastula;* MAR.—*Jhankara;* W. INDIA—*Kala kirayat*) is a herb, up to 3 ft. high, with ovate, acuminate, long-petioled leaves and axillary whorls of dark lilac flowers surrounded by numerous spiny cladodes. It occurs in the hills of the Deccan Peninsula and in parts of western and central India. *H. tentaculatus* Nees is a closely related species occurring in similar situations and known by the same vernacular names. Both the herbs are reported to be given in fever (Kirt. & Basu, III, 1887).

## HARDWICKIA Roxb. (*Leguminosae*)

A small genus of trees distributed in tropical Asia and Africa. One species occurs in India.

**H. binata** Roxb.

D.E.P., IV, 200; Fl. Br. Ind., II, 270.

SANS., HINDI & MAR.—*Anjan;* TEL.—*Yepi, epe, naraepe;* TAM.—*Acha, calam, katudugu;* KAN.—*Kamra, karachi, acca.*

BOMBAY—*Parsid;* GOND—*Chhota-dundhera.*

TRADE—*Anjan.*

A handsome deciduous tree, up to 120 ft. in height and 15 ft. in girth, with a clean cylindrical bole 40–50 ft. in length, found in the dry savannah forests of the Deccan Peninsula, Central India and

FIG. 5. HARDWICKIA BINATA

parts of U.P. and Bihar. It is occasionally cultivated in the plains. Bark dark grey, rough, peeling off in papery flakes; leaves alternate, bifoliolate: leaflets sessile, entire, obliquely-ovate, coriaceous; flowers yellowish green, in lax panicles; pod strap-shaped, narrow at both ends with seed near the tip.

*H. binata* thrives in a dry climate and is capable of growing on dry shallow soil and rocky ground. Its best development is attained in porous sandy loams and reddish gravelly sand overlying sandstones, conglomerates, granites and schists. It is frost- and drought-hardy; its rate of growth is rather slow, the mean annual growth increment being 0.63 in. The tree coppices indifferently, but pollards well. It reproduces vegetatively by root suckers.

The tree sheds its pods in May and seeds germinate at the commencement of the rains. The factors favouring natural reproduction are: porosity and depth of soil, protection from sun in the early stages, and prevention from fire and grazing. Artificial propagation is by direct sowing or transplanting, the former being more successful (Troup, II, 340-61).

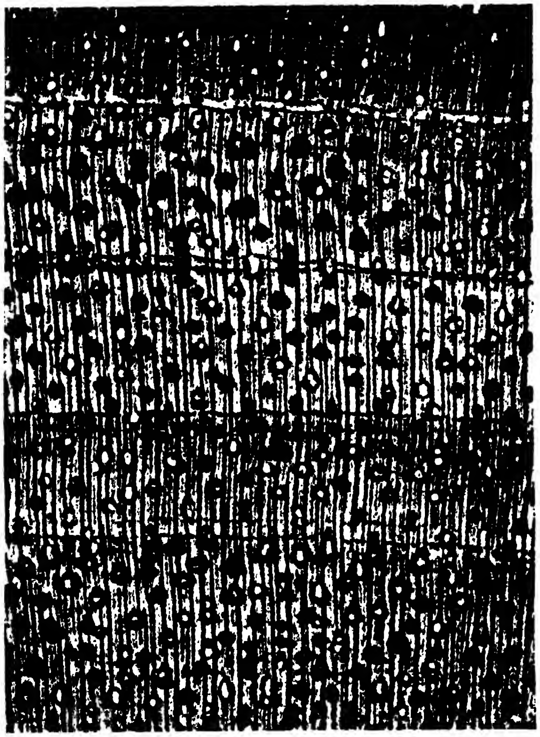
*H. binata* yields an extremely hard, very heavy (sp. gr., 1.08; wt., 69 lb./cu. ft.) and durable timber, known in the trade as Anjan. It is dark red to dark brown in colour with darker streaks, often with a purplish cast, dull with oily feel, irregularly interlocked-grained and coarse-textured. It is difficult to air-season as it develops cracks; water-seasoning with green conversion is recommended. The timber is durable and resistant to rot and white ants; it is, however, liable to attack by borers. Untreated sleepers give an average life of 10–15 years in graveyard tests. It is an extremely difficult timber to saw and work when seasoned. It can be turned and finished to a very smooth surface on the lathe (Pearson & Brown, I, 411, 413; Trotter, 1944, 111).

The data for the comparative suitability of anjan as timber, expressed as percentages of the same properties of teak, are: wt., 125; strength as a beam, 75; stiffness as a beam, 60; suitability as a post, 70; shock-resisting ability, 125; retention of shape, 90; shear, 145; and hardness, 180. It is a moderately good fuel wood (calorific value: *sapwood*, 4,891 cal., 8,804 B.t.u.; *heartwood*, 4,952 cal., 8,915 B.t.u.) [Limaye, *Indian For. Rec., N. S., Util.*, 1944, **3** (5), 18; *Indian For.*, 1948, **74**, 280; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 18].

Anjan wood is largely used locally for naves of cart wheels, oil mills, ploughs, clod crushers and for

*Bot. Dep., Pres. College, Madras*

FIG. 6. HARDWICKIA BINATA—FRUITING BRANCH



*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 7. HARDWICKIA BINATA—TRANSVERSE SECTION OF WOOD (× 10)

posts and beams, mine props, bridges, wells, pontoons, oars and parquet floors. It is used also for carving, turning and ornamental work. It is suitable for bench screws, lathe chucks, tool handles, sheaves of rope blocks, railway keys, tent pegs and brake blocks. It is used as a substitute for Lignum Vitae (from *Guaiacum officinale*) for bearings (Pearson & Brown, I, 413 14: Naidu, 74; Trotter, 1944, 111).

Destructive distillation of the wood gave the following products: charcoal, 31.8; pyroligneous acid, 41.4 (dry); tar, 5.9%; non-condensable gas, 1.75 cu. ft. at NTP/lb. The ash of the wood (2.58%) contained the following constituents (silica-free basis): iron ($Fe_2O_3$)+aluminium ($Al_2O_3$), 0.11; calcium (CaO), 55.5; magnesium (MgO), 2.48; potassium ($K_2O$), 9.15; sodium ($Na_2O$), 3.99; sulphur ($SO_3$), 0.58; chlorine (Cl), 0.39; and phosphorus ($P_2O_5$), 2.29% (Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B**, 125, 217).

The bark yields a red-brown fibre used for well ropes and other agricultural purposes. The leaves are used as cattle fodder and manure. The tree is often pollarded not only for the fodder and manure supplied by the leaves, but also for the fibre obtained from the young branches. Chemical analysis of the leaves gave the following values: moisture, 7.78; ash, 9.14; protein, 10.79; fat, 5.21; fibre, 28.21; carbohydrates, 38.87; lime (CaO), 4.10; and phosphoric acid ($P_2O_5$), 0.24% (Trotter, 1940, 230; Troup, II, 340; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 17).

**Hardwickia pinnata** — *see* **Kingiodendron**

**Hares** — *see* **Rodents**

**Haricot Beans** — *see* **Phaseolus**

**HARPEPHYLLUM** Bernh. (*Anacardiaceae*)

Bailey, 1947, II, 1432.

A small genus of dioecious trees native of S. Africa. *H. caffrum* Bernh. (KAFIR PLUM), a tall glabrous tree 30 ft. high, has been introduced into India and tried in Nilgiri hills, Tinnevelly and Coimbatore districts of Madras State and Malabar district of Kerala. Leaves thick, lustrous, compound; fruit dark red, of the size and shape of a large olive, with very thin pulp of subacid taste, edible; wood hard and heavy. The fruit pulp contains citric and malic acids. The tree bark contains 18% tannin and is used as a tanstuff; it yields a soft pinkish red leather of good texture. A decoction of the bark is reported to be used by Zulus in S. Africa as an emetic and blood purifier (Lushington, IIA, 179; Watt & Breyer-Brandwijk, 108; Howes, 1953, 279).

**HARPULLIA** Roxb. (*Sapindaceae*)

A genus of trees distributed in the tropical regions of the Old World. Two species occur in India.

**H. arborea** (Blanco) Radlk. syn. *H. imbricata* Thw.; *H. cupanioides* Hiern (Fl. Br. Ind.) in part, non Roxb.

Fl. Br. Ind., I, 692; Talbot, I, Fig. 201.

TAM.—*Nei-kottei*; KAN. *Bidsale*; MAL.—*Chittila madakku*; ORIYA—*Phutika*.

An ornamental tree, up to 60 ft. high, with a clean bole, found in Assam, Orissa and western ghats, ascending up to an altitude of 4,000 ft. Bark light brown; leaves pinnate, 6–18 in. long: leaflets ovate-elliptic, oblique at the base, pale beneath, coriaceous; flowers pale yellow, in lax panicles; capsules pendulous, didymous, bright orange; seeds subglobose, black, arillate, one or two in each lobe.

The fruit contains saponaceous matter and is used for washing purposes. The bark is used as a substitute for *Entada phaseoloides* as hair wash; it is

also used as fish poison. The fruit and the bark are used to prevent leech bites. The oil from the seeds is sometimes used as an antirheumatic (Brown, 1941, II, 364).

*H. cupanioides* Roxb. syn. *H. cupanioides* Hiern (Fl. Br. Ind.) in part, is a closely related species found in parts of Assam and Andaman Islands.

**Hausmannite** — *see* **Manganese Ores**

**Hawthorn, English** — *see* **Crataegus**

**Hazel** — *see* **Corylus**

**HEDERA** Linn. (*Araliaceae*)

A genus of climbing shrubs and small trees, commonly known as Ivies, distributed in the temperate regions of the Old World. One species occurs in India.

**H. helix** C. B. Clarke (Fl. Br. Ind.), non Linn.= *H. nepalensis* Koch syn. *H. himalaica* Tobler Nepal Ivy

D.E.P., IV, 205; Fl. Br. Ind., II, 739; Kirt. & Basu, Pl. 486 B.

Hindi—*Lablab*.

Punjab—*Banbatkari, banda, kadloli, karbaru, kuri*; Kashmir—*Hari-bumbal, karmora, mandia*; Kulu—*Kermi*; Jaunsar—*Mithiari*; Kumaon—*Banda*; Nepal—*Dudela*; Assam—*Mej-peosree*.

A large evergreen woody climber with stems sometimes up to 1 ft. in diam., climbing by means of numerous adventitious rootlets, found throughout the Himalayas ascending to an altitude of 10,000 ft. and in the hilly parts of Assam between 4,000 and 6,000 ft. Leaves alternate, simple, very variable from linear-lanceolate to cordate-ovate; those of vegetative shoots usually more deeply lobed than those of flowering shoots; flowers yellowish green, polygamous, in globose pedunculate umbels; berry globose (*c.* 3 in. diam.), yellow or red; seeds 3–5, ovoid.

Nepal ivy was, till recently, considered to be synonymous with the English ivy, *H. helix* Linn. and most Indian authors have not discriminated between the two in describing the uses. The ivy grown in Nilgiris for ornamental purposes is reported to be identical with the English ivy.

Ivy was once greatly valued in medicine, but is now almost completely discarded. Leaves and berries are reported to be stimulant, diaphoretic and cathartic.

*Bot. Dep., Pres. College, Madras*

FIG. 8. HEDERA HELIX—FLOWERING BRANCH

Fresh leaves have a balsamic odour and bitter taste. In Kulu, they are added to country beer to make it 'strong'. A decoction of the leaves is applied externally to destroy lice in the hair. Leaves are reported to be poisonous when eaten and contact with them may cause dermatitis in some persons. They are eaten by cattle and no case of poisoning in animals has been recorded (Kirt. & Basu, II, 1235; U.S.D., 1947, 1475).

An infusion of the berries is given in rheumatism. Ivy gum, a resinous exudate from the stems of old plants, is used as stimulant and emmenagogue (Chopra *et al.*, 523).

Nearly all parts of the plant, leaves, berries and seeds, contain α-hederin ($C_{42}H_{66}O_{11}$), a glycoside which on hydrolysis gives hederagenin ($C_{30}H_{48}O_4$), *l*-arabinose and rhamnose. They contain also other glycosides, propably saponins, which have not been characterised. Hederin is intensely haemolytic and acts as an irritant to the alimentary canal, causes vaso-constriction, lowers the blood pressure, slows the heart and may cause death by paralysis of respiration. The seeds contain a semi-drying oil (20–32%)

with the following characteristics: m.p., 25.2° ; sp. gr., 0.9151 ; *n*, 1.4670 ; acid val., 11.0 ; sap. val., 181.1 ; iod. val., 102.2 ; R.M. val., 1.0 ; and unsapon. matter, 6.5%. The mixed acids (m.p., 23-24° ; iod. val., 97.2 ; mean mol. wt., 281.9) consist of palmitic, 5.1 ; petroselenic, 62 ; and oleic and linoleic acids, 20% (U.S.D., loc. cit. ; Thorpe, VII, 72 ; McIlroy, 66 ; Wehmer, II, 869 ; *Chem. Abstr.*, 1941, **35**, 3032 ; Chopra *et al.*, 524 ; Krishna *et al.*, *Indian For. Rec., N.S., Chem.*, 1936, **1**, 34).

**HEDGEHOGS, MOLES AND SHREWS** (Class, *Mammalia* ; Order, *Insectivora*)

Hedgehogs, moles and shrews belong to an order of a little over 400 species of small, but much diversified, types chiefly confined to the Old World. They are probably the most primitive among placental mammals. They are mostly terrestrial, but some are subterranean and a few arboreal. The majority feed on insects and worms, and at times, on snakes and scorpions also, while a few arboreal forms subsist on leaves. With few exceptions they are nocturnal and can easily be identified by their pig-like nose. Their chief features are: pointed dentition ; clongated skull ; and short, five-toed, plantigrade limbs resembling those of rodents. The order is divided into four families, namely, the Hedgehogs (*Erinaceidae*), the Moles (*Talpidae*), the Shrews (*Soricidae*), and the Tree Shrews (*Tupaiidae*) ; all have their representatives in India (Jerdon, 49–50 ; Prater, 130 ; Sterndale, 43 ; Thomson, 894-95).

**Hedgehogs** (Family, *Erinaceidae ;* sub-family, *Erinaceinae*).

D.E.P., VI (1), 398 ; Fn. Br. Ind., Mammalia, 212 ; Jerdon, 61 ; Prater, 132 ; Reese, 243 ; Sterndale, 48.

HINDI—*Kanta chua, kanderna, sinh.*

PUNJAB—*Kharpusht, jujuk.*

The hedgehog is a small mammal about the size of a guinea pig, with inconspicuous tail and a covering of short, usually black and white, spines above and a short fur on the under parts. Eyes and nose are pig-like and easily distinguished from those of a baby porcupine.

Hedgehogs feed on insects and other small animals and are nocturnal in habit, hiding themselves in holes or burrows under dense bushes excavated by their own efforts. When disturbed, they draw in their snout and limbs, and roll up into an impregnable ball with erect spines. Indian forms are known to hibernate.

Two main genera of hedgehogs are known in India, viz., *Hemiechinus* Fitzinger and *Paraechinus* Trouessart.

Hardwicke's Collared Hedgehog, *Hemiechinus auritus collaris* (Gray) (KUTCH—*Sevro, sewra*), inhabits the dry desert zones of Kutch and Rajasthan and the Punjab extending eastwards probably as far as Kanpur in U.P. The animal is unknown in hilly areas. It feeds mainly on insects, but is also known to eat lizards and snails. Its breeding habits are not known (Ishwar Prakash, *Proc. Rajasthan Acad. Sci.*, 1956, **6**, 24).

Anderson's Hedgehog, *Paraechinus hypomelas blanfordi* (Anderson), is found in Punjab. Little information is available on its habits. Pale Hedgehog, *P. micropus* (Blyth) (TAM.—*Mollu-yelli*) occurs in Punjab, Rajasthan, Kutch, Kathiawar, Palanpur and in Madras, Tiruchirapalli, Coimbatore and in the eastern slopes of Nilgiris towards the base. *P. m. micropus* (Blyth) is confined to Ratangarh and Jhunjhunu in Rajasthan and Punjab ; it has been also recorded from Tiruchirapalli and Coimbatore districts in Madras. *P. m. nudiventris* (Horsfield) resembles the pale hedgehog in colour and is restricted to the plains of S. India (Ellerman & Morrison-Scott, 24–9 ; Wroughton, *J. Bombay nat. Hist. Soc.*, 1910, **20**, 80 ; 1912, **21**, 832 ; Daya Krishna & Ishwar Prakash, ibid., 1955, **53**, 39).

Hedgehogs are not considered to be of much economic value, although their feeding on insects and worms is beneficial to agriculture. They are sometimes eaten as food after roasting. In Punjab, the flesh is said to be pounded with ghee into an ointment for application to chronic ulcers. Exposure to fumes emanating from the burnt spines is believed to relieve pain due to haemorrhoids. The fat of the hedgehog is used as an external application for rheumatic swellings.

**Moles** (Family, *Talpidae ;* sub-family, *Talpinae*)

D.E.P., VI (1), 397 ; Fn. Br. Ind., Mammalia, 222 ; Jerdon, 50 ; Prater, 133 ; Reese, 242 ; Sterndale, 43.

Sausage-shaped animals with very short limbs and tails and possessing sharp, cusped cheek teeth without modification in front teeth, as in shrews. Eyes and ears not noticeable ; dentition primitive with six small and sub-equal incisors above and below, and a tusk-like upper canine. Except for a few members, which are adapted for aquatic habits, the family consists mainly of subterranean forms.

The mole is a miracle of specialisation for

underground life. Its limbs function as shovels for scooping out the earth loosened by its powerful snout; the eyes are degenerated to mere vestiges. It can tunnel through the earth at a speed of 10-12 ft. an hour, leaving mole hills behind to mark the areas of operations. It is most efficient in capturing earthworms and insect larvae and it needs more than its own weight of worms and grubs every day to keep itself alive. It sometimes feeds on snails, slugs, mice, shrews and frogs (Huxley, J. & Suschitzky, 25).

Little is known regarding its breeding habits. Usually 3-4 young are born, the gestation period being six weeks.

The Short-tailed Mole, *Talpa micrura micrura* Hodgson (Lepcha—*Pariam*; Bhutia—*Biyu kantyem*), inhabits western Himalayas, Nepal, Sikkim, Khasi hills, Mikir hills and the hills south of Assam. It is about 5 in. long with tail *c.* 1/8 inch in length: fur velvet-like, steely black (brown in dried skins): snout and feet flesh-coloured. It does not usually form mole hills.

The White-tailed Mole, *T. micrura leucura* Blyth (Khasi—*Kyndat*), is abundant in Darjeeling, Khasi, Jaintia and Naga hills (up to 10,000 ft.), and in southern Assam. They are smaller than the short-tailed species, with brown fur, short muzzle and club-shaped tail with long white hair. They emit an offensive smell when handled or confined in a box (Ellerman & Morrison-Scott, 39–40; Wroughton, *J. Bombay nat. Hist. Soc.*, 1916, **24**, 480, 779; Hinton & Lindsay, ibid., 1926, **31**, 390).

The skins of moles are used as furs. The animals are sometimes eaten. They are useful in aerating and turning up the soil.

**Shrews** (Family, *Soricidae*; sub-family, *Soricinae*).

D.E.P., VI (1), 397; Fn. Br. Ind., Mammalia, 227; Jerdon, 52; Prater, 134; Reese, 242; Sterndale, 44.

The shrews constitute the most numerous and widespread family of insectivores. They are small and mouse-like in appearance with long and pointed snout; eyes small; ears rounded; coat soft and silky; tail with short hair; teeth distinctive: two large, pointed and rather hooked incisors in the upper jaw and two large, but slightly incurved, incisors opposing them in the lower: other incisors and canines found only in the upper jaw. When disturbed, shrews emit an unpleasant musky odour, emanating from the secretion of glands on the sides of the body found only in males. One to three young are born at a time. Generally shrews are more short-lived than rats. Economically they are not of much value except that they are insectivores.

Shrews of 10 generic types with some 80 species are known to occur in India. Five species are noteworthy; they are: the House Shrew, *Suncus murinus caerulescens* (Shaw) (Hindi—*Chachundar*; Kan.—*Sondeli*; Mal.—*Kondeli*; Kashmiri—*Anachiwagagur*); Savi's Pygmy Shrew, *S. etruscus perrotteti* (Duvernoy); the Sikkim Large-clawed Shrew, *Soriculus nigrescens nigrescens* (Gray) (Lepcha—*Tangzhing*; Bhutia—*Ting-zing*); the Himalayan Water-Shrew, *Chimmarrogale platycephala himalayica* (Gray) (Lepcha—*Ung-lagniyu*; Bhutia—*Chupitsi*); and Szechuan Water Shrew, *Nectogale elegans sikhimensis* de Winton & Styan (Lepcha—*Ung-cloh*; Bhutia—*Chupichi*) (Ellerman & Morrison-Scott, 58, 65–8, 88–9).

**Tree Shrews, Tupaias** (Family, *Tupaiidae*; sub-family, *Tupaiinae*).

Fn. Br. Ind., Mammalia, 207; Jerdon, 64; Prater, 131; Sterndale, 52.

The tree shrew is a combination of a shrew and a squirrel with shrew-like snout and ears, and squirrel-like body, limbs and tail, feet resembling those of squirrel with naked soles, long toes and supple, moderately curved claws well adapted for climbing trees. They busily move about on the ground in search of food, which consists of insects, small mammals, birds and, at times, fruits. Three young ones are born at a time; little is known about their breeding habits. Economically tree shrews are of no particular importance.

Three species of tree shrews belonging to genera *Anathana* and *Tupaia*, occur in India. To the former belong three forms of the Madras Tree Shrew (Tam.—*Munghil Anathan*), viz., *Anathana ellioti ellioti* (Waterhouse), *A.e. wroughtoni* Lyon and *A.e. pallida* Lyon. Similarly four forms are known of the Common Tree Shrew, viz., *Tupaia glis chinensis* Anderson (Lepcha—*Kallitong-zing*), *T.g. assamensis* Wroughton (Garo—*Mad*; Khasi—*Kmud*), *T.g. versurae* Thomas (Mishmi—*A'chubua*) and *T.g. lepcha* Thomas (Lepcha—*Ting-zhing*). The Nicobar Tree Shrew belongs to *Tupaia nicobarica nicobarica* (Zelebor) (Ellerman & Morrison-Scott, 10–12).

**HEDYCHIUM** Koenig (*Zingiberaceae*)

A genus of herbs, sometimes epiphytic, commonly known as Ginger Lilies, distributed chiefly in tropical and sub-tropical Asia. Some of them are

cultivated for their ornamental foliage and sweet scented flowers. Some yield fibre suitable for paper manufacture. About 30 species occur in India.

Ginger lilies are propagated by divisions of rhizome and grow like cannas. They require a rich soil with plenty of water and, occasionally, liquid manure. Swampy ground on the sides of drains and moist semi-shady situations are well suited for them (Gopalaswamiengar, 492).

**H. coronarium** Koenig COMMON GINGER LILY, GARLAND FLOWER

Fl. Br. Ind., VI, 225.

A stout perennial herb, 3–7 ft. in height, occurring throughout the moist parts of India up to an altitude of 7,000 ft. Rhizome horizontal, fleshy, 1–2 in. thick, bearing erect leafy shoots; leaves large with long clasping sheaths, sessile, distichous, oblong-lanceolate, acuminate, more or less glabrous beneath; flowers in terminal spikes, white, showy, fragrant, imbricated by broad bracts; capsule oblong, glabrous; seeds many, arillate.

The plant is commonly grown in gardens and succeeds best in rich deep soil with abundant supplies of water. Experimental planting carried out in the Forest Research Institute, Dehra Dun, with a view to study its possibilities as a raw material for paper-making has shown that the rhizomes root readily provided there is sufficient water in the soil. Rhizomes from the previous year generally sprout with the advent of summer rains and the plants grow vigorously in warm and moist weather. Flowering commences about the middle of September after which the growth declines and the leaves turn yellow. Plants are in full flower during the first half of October after which they fade. Stems are ready for harvesting in the beginning of November. A yield of approximately 1½ tons of dried stems per acre in the open and 2¼ tons per acre under the shade of *Casuarina* plants may be expected (Dabral, *Indian For.*, 1946, **72,** 118).

The aerial stems constitute a useful raw material for paper manufacture. Dried whole stems contain 43% cellulose, while those passed through crushing rollers before drying contain 48% cellulose; the length of the ultimate fibres averages 2.61 mm. and the pith cells average 0.11 mm. in diam. Dressed fibre free from green stems possesses tensile strength comparable to that of the best manila binder twine. Stems passed between crushing rollers prior to drying form a convenient material for the preparation of pulp by the soda process. The yield of pulp, including pith cells, is 60%; pith cells can be removed by washing, when the yield of fibre is 50% on the weight of the raw material. The presence of pith cells in the pulp confers on the paper produced, parchment-like properties and renders the paper ink-bearing without the addition of any sizing material; also the paper produced has exceptional strength, elasticity and folding qualities. On the other hand, papers made from *Hedychium* stems from which these cells are removed are of a soft nature and medium strength. Dried whole stem specimens (not crushed between rollers prior to drying) from the Botanic Garden, Sibpur (Calcutta) have also been

FIG. 9. HEDYCHIUM CORONARIUM—FLOWERING BRANCH

tested for their suitability as raw material for paper-making. The yield of unbleached paper was reported to be 32.5%. The material boiled down readily, was easily beaten to pulp, drained and felted well when made into paper, and had good wet strength after couching. The waterleaf was not ink-proof which showed that the stem juice, which had not been pressed out, had some effect on the natural constituents which gave *Hedychium* fibre the peculiar self-sizing quality. Trials carried out at the Forest Research Institute, Dehra Dun have also given promising results. The yield of paper was 52.4% on the air-dry weight of the material and the paper possessed remarkably high resistance to folding and breaking length (*Kew Bull.*, 1912, 374; 1914, 165; *Chem. Abstr.*, 1912, **6,** 3017; 1913, **7,** 889; Dabral, loc. cit.).

The rhizomes contain starch which is similar to arrowroot starch. Analysis of rhizomes from the Philippines gave the following values:- starch, 3; glucose, 4.58; albumen, 1.65; fat, 0.33; resinous acid, 3.66; resin, 5.93; extracted matter, 0.91; gums, 13.75; organic acid, 5.5; and cellulose, 29.6% (*Hort. Abstr.*, 1953, **32,** 137).

Air-dried rhizomes, on steam-distillation, yield 0.124% of a volatile oil with the following characteristics: sp. gr.$^{26°}$, 0.821; $n_D^{28°}$, 1.4625; $[\alpha]_D^{29°}$, $-2°$; iod. val., 108.9; acid val., 2.8; and ester val., 17.27 (after acetylation, 74.71). The oil contains 16% of aldehydes and other compounds soluble in sodium sulphite; phenols and sesquiterpenes are also present (*Chem. Abstr.*, 1941, **35,** 4916).

The flowers are used as a source of perfume in Hawaii. They contain 0.023–0.029% ethereal oil (sp. gr., 0.869; $[\alpha]_D$, $-0.47°$) with a pleasant but delicate flavour (Neal, 215; Gildemeister & Hoffmann, II, 276).

The plant is reported to be used in Hawaii as a remedy for foetid nostrils. The rhizome is ground and used as a febrifuge by the Mundas of Ranchi district (Bihar). A decoction of the rhizome is considered antirheumatic, tonic and excitant; in Moluccas, it is used as a gargle; the base of the stems is chewed and the juice obtained is applied to swellings (Bushnall *et al.*, *Pacif. Sci.*, 1950, **4,** 167; Burkill, I, 1129; Quisumbing, 192; Bressers, 150; *Hort. Abstr.*, 1953, **23,** 137).

**H. spicatum** Buch.-Ham. SPIKED GINGER LILY

D.E.P., IV, 207; Fl. Br. Ind., VI, 227.

SANS.—*Karpurakachali, gandhashati;* HINDI, BENG., MAR. & GUJ.—*Kapurakachari;* TAM.—*Shimai-kichchilik-kishangu;* KAN.—*Gandhashati.*

PUNJAB & KUMAON HILLS—*Sheduri, sitruti.*

A perennial rhizomatous herb, *c.* 3 ft. high, occurring in parts of western and central Himalayas at altitudes of 3,500–7,500 ft. It closely resembles *H. coronarium*, but the leaves are glabrous beneath and the white ascending flowers are borne in dense terminal spikes.

The rhizomes possess strong aromatic odour and bitter camphoraceous taste. They are an article of commerce (INDIAN BAZAAR—*Kapurkachari;* BENGAL—*Ekangi*) and are sold in the form of slices (0.5 inch or less in diam. and up to 0.25 inch in thickness). They are white and starchy within, covered by rough reddish brown bark, with rootlets

FIG. 10. HEDYCHIUM SPICATUM

attached here and there. *Kapurkachari* is employed in the preparation of *Abir*, a fragrant coloured powder used during the Holi festival and in religious ceremonies. The rhizomes are also considered to have insect-repelling properties and are used for preserving clothes. They may be employed as an auxiliary in dyeing to impart a pleasant smell to fabrics; in some parts of North India, they are used with *henna* to produce perfumed cloth known locally as *malagiri* cloth. Pounded rhizomes are reported to be used also for perfuming tobacco.

The rhizomes are stomachic, carminative, stimulant and tonic, and are used in dyspepsia in the form of powder or decoction. They enter into the preparation of cosmetic powders used for promoting hair growth. They are used in Bengal, after frying and mixing with other ingredients, as *chars* or perfumed baits for fish. They are much used in veterinary medicine (Nadkarni, I, 608; Dastur, Useful Plants, 122; Tayal & Dutt, *Proc. nat. Acad. Sci. India*, 1940, **10A**, 47).

The dried rhizomes of commerce on steam-distillation yield *c.* 4% of an essential oil with the characteristic odour and pungent taste of the rhizome. It contains as its principal constituent (67.8%) the ethyl ester of *p*-methoxy cinnamic acid ($C_{12}H_{14}O_3$; m.p., 49–50°). The original oil and the oil from which the ester has been removed through crystallisation have respectively the following characteristics: sp. gr.$^{30°}$, 0.8824, 0.8910; $n_D^{30°}$, 1.4784, 1.4810; and sap. val., 180.4, 115.4 (after acetylation, 195.4, 125.9). Besides the ester, the essential oil contains: ethyl cinnamate, 10.2; *d*-sabinene, 4.0–4.2; 1,4 cineole, 6.0; sesquiterpene (probably cadinene), 5.5; sesquiterpene alcohols, 4.7; and unidentified substances, 1.8%, with some pentadecane ($C_{15}H_{32}$) and traces of cinnamaldehyde. The oil may be used as a perfume for soaps, hair oils and face powders and as incense (Tayal & Dutt, loc. cit.; Dymock, Warden & Hooper, III, 419; Finnemore, 182; Wehmer, I, 179; *Chem. Abstr.*, 1940, **34**, 6015).

Besides the essential oil, the rhizomes contain starch (52%), organic acids including resinic acid, a glycoside, and ash (4.6%) (Wehmer, I, 179).

The leaves are woven into mats. The dried fruit is reported to be added to soften meat and pulses during cooking.

*H. flavum* Roxb. syn. *H. coronarium* var. *flavum* Baker (Fl. Br. Ind.) (Yellow Ginger Lily) is a coarse perennial herb, closely allied to *H. coronarium*, bearing delicate yellow fragrant flowers during the rainy months. It has been recorded from the valleys near Sylhet and is grown in gardens.

The flowers yield 0.05 to 0.07% of a dark maroon-brown wax-like concrete (m.p., 37°; acid val., 20; ester val., 98) with a strong spicy odour. It gives 50–57.8% of a thick oily absolute of dark orange-brown colour and a hard brownish black wax (m.p. variously reported as 43–44° and 60–61°). A straw yellow oil has been obtained on steam-distillation of the concrete (yield, 19%) and the absolute (yield, 18.8%). This oil has the following characteristics: sp. gr.$^{20°}$, 0.9525; $n_D^{20°}$, 1.4936; $[\alpha]_D$, −9.60°; acid val., 8.3; and ester val., 54.6; phenols, 23.3% (by vol.); methoxyl content, 5.12%. The oil contains eugenol, benzoic acid, linalool, linalyl acetate and methyl anthranilate; a product with an acetophenone and cuminaldehyde-like odour has also been isolated. The oil is used in high grade perfumes to impart heavy and exotic tonalities (Guenther, V, 132; Naves & Mazuyer, 185; Naves & Ardizio, *Perfum. essent. Oil Rec.*, 1952, **43**, 231).

## HEDYOTIS Linn. (*Rubiaceae*)

A genus of herbs and shrubs distributed in the tropical and subtropical regions of the world. About seventy species occur in India, some of which are used in medicine.

**H. auricularia** Linn. syn. *Oldenlandia auricularia* K. Schum.

D.E.P., IV, 208; Fl. Br. Ind., III, 58.

Beng.—*Muttia-lata.*

Bombay—*Dapoli*; Madras—*Kudal-churiki.*

A prostrate or suberect annual, occurring in the north-eastern parts of India and the Deccan Peninsula. Leaves sessile or shortly stalked, ovate or lanceolate, acuminate; flowers small, white, in axillary cymes; capsules globose, hard, indehiscent, crowned by persistent calyx.

The herb is a popular remedy in early cholera, diarrhoea, dysentery, colitis and other abdominal complaints. It is administered in the form of extract or decoction, or a bolus made from fresh leaves. In Konkan, the herb is employed as a prophylactic against enteric fever. A paste of the leaves is considered emollient and applied to abscesses and wounds. The plant is also reported to be used in deafness. In Ceylon, boiled leaves are eaten with rice (Dastur, Medicinal Plants, 131; Chandrasena, 121).

The stems and roots contain an unstable alkaloid hedyotine ($C_{16}H_{22}O_3N_2$), a crystalline alkaloid

auricularine ($C_{42}H_{55}ON_5$ ; m.p., 201°) and some amorphous bases ; the total alkaloid content is 0.29%. Other constituents reported to be present are: fatty matter yielding on saponification stearic and linoleic acids, a phytosterol (m.p., 141–42°), alizarin, oxalic acid, glycosides, reducing sugars, colouring matter, tannins and albumin (Ratnagiriswaran & Venkatachalam, *J. Indian chem. Soc.*, 1942, **19,** 389 ; Wehmer, suppl., 100).

**H. biflora** (Linn.) Wight & Arn. syn. *Oldenlandia paniculata* Burm. f. (Fl. Br. Ind.), non Linn. ; *O. biflora* Linn.

Fl. Br. Ind., III, 69, 70 ; Fl. Madras, 602.

HINDI—*Daman-papra* ; BENG.—*Khet-papra.*

An erect or diffuse glabrous annual, found in north-east India and Carnatic coast. Branches 4-angled or winged ; leaves thin, elliptic, subacute ; flowers white, in terminal or axillary, few-flowered cymes ; capsules turbinate.

The plant is used in remittent fever, gastric irritation and nervous depression* (Kirt. & Basu, II, 1266).

**H. corymbosa** (Linn.) Lam. syn. *Oldenlandia corymbosa* Linn.

D.E.P., V, 480 ; Fl. Br. Ind., III, 64.

SANS. *Kshetraparpata* ; HINDI—*Daman-papar, pitpapra*† ; BENG.—*Khet-papra* ; MAR.—*Khet-papda, paripat* ; GUJ.—*Khet-papra, parpat* ; TEL.—*Verinella-vemu* ; TAM.—*Parpadagam* ; KAN.—*Kallasabatrasige.*

NEPAL—*Piriengo.*

A spreading, suffruticose annual, up to 15 in. high, frequently met with in fields throughout India, usually during the rainy season. Leaves small, linear or narrowly elliptic-lanceolate, often with recurved margins ; flowers white, 1–3, rarely 4, in axillary pedunculate cymes ; capsules globose, pyriform or somewhat didymous.

The plant is considered to possess cooling, febrifugal, pectoral and stomachic properties. It is usually administered in the form of a decoction in remittent fever with gastric irritability and nervous depression caused by deranged bile. It is also given in jaundice and diseases of the liver and as a cure for heat eruptions. The juice of the plant is applied to palms and soles to relieve the burning sensation in fevers. The plant is also used as an anthelmintic. In Philippines, the plant is boiled in water and the brew used as mouth wash in toothache (Kirt. & Basu, II, 1264 ; Quisumbing, 921 ; Fox, *Philipp. J. Sci.*, 1952, **81,** 341).

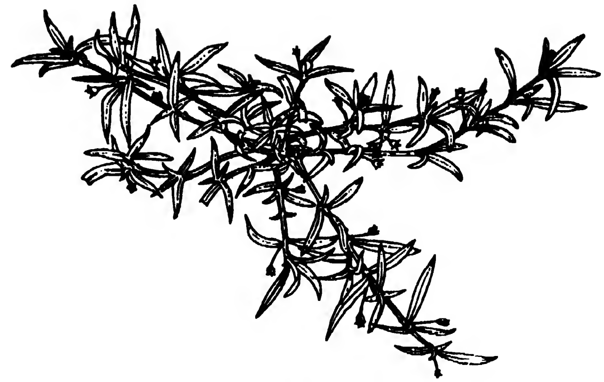


FIG. 11. HEDYOTIS CORYMBOSA—FLOWERING BRANCH

The cooling property of *H. corymbosa* is attributed to the presence of inorganic salts (ash content, 13.76%). The air-dried plant contains 0.12% alkaloids, biflorine ($C_{17}H_{17}O_4N$ ; white, crystalline, m.p., 206°) and biflorone ($C_{17}H_{15}O_4N$ ; yellow, crystalline, m.p., 98°) ; the alkaloids are interconvertible. In stored plants, the concentration of biflorone increases at the cost of biflorine ; plants stored for 3–4 years do not contain any alkaloids (Dymock, Warden & Hooper, II, 199 ; Chauhan & Tiwari, *J. Indian chem. Soc.*, 1952, **29,** 386 ; 1954, **31,** 741).

**H. herbacea** Linn. syn. *Oldenlandia herbacea* Roxb. ; *O. heynii* R. Br.

Fl. Br. Ind., III, 65 ; Fyson, II, Fig. 216.

An erect, much-branched, glabrous annual or biennial, found in hilly districts almost throughout India up to an altitude of 5,500 ft. Leaves sessile, linear-lanceolate ; flowers small, solitary or in paniculate axillary cymes ; capsules subglobose, somewhat didymous.

The plant is used as a bitter tonic and febrifuge. Its extract or decoction has been reported to be useful in the treatment of malaria. A decoction of the herb is also used for bathing rheumatic patients and the powdered herb is administered with honey for rheumatic fever and swellings. The herb is boiled in oil and the oil used in elephantiasis and pains in the body. The leaves are employed as expectorant in asthma and consumption. The root bark is used as a dyeing material (Bressers, 75 ; Kirt. & Basu, II, 1265 ; Rama Rao, 205).

* This species and the allied *H. corymbosa*, *H. diffusa* and *H. herbacea* do not seem to be much discriminated in their medicinal uses.

† The name *Pitpapra* appears to be a misnomer. The genuine *Pitpapra* is the fumitory, *Fumaria* spp. (q.v.).

**H. scandens** Roxb. syn. *Oldenlandia scandens* K. Schum.

Fl. Br. Ind., III, 57.

NEPAL—*Bokri lahara* ; ASSAM—*Bhedeli lot.*

A slender woody climber, found from Nepal to Assam up to an altitude of 6,000 ft. Leaves opposite, oblong or elliptic-lanceolate, 2.75–4.25 in. × 0.65–1.5 in., sub-coriaceous; flowers white, later turning creamy, in axillary and terminal, puberulous cymes; capsules small, globose.

The leaves of the plant are eaten; they are also used as a green dye by Lepchas. The plant is used in eye diseases and troubles following child birth. The root is used for sprains. The capsules are used in North Bengal for blackening teeth (Cowan & Cowan, 77; Fl. Assam, III, 38).

The plant contains a glycoside and two crystalline compounds, all related to rotenone, and active as fish poisons. A crystalline yellow substance, which is inactive as fish poison, has also been isolated (Ameen & Ahmad, *Proc. Pakist. Sci. Conf.*, 1953, pt III, 119).

Uses more or less similar to those of *H. scandens* have been ascribed to *H. capitellata* Wall. ex G. Don, a species found in China, Malaya and Burma, and also recorded from Manipur in Assam. Its occurrence in Darjeeling and the Terai area seems to be a case of mistaken identity for *H. scandens.*

**H. umbellata** (Linn.) Lam. syn. *Oldenlandia umbellata* Linn. CHAY-ROOT, INDIAN MADDER.

D.E.P., V, 481; C.P., 821; Fl. Br. Ind., III, 66; Kirt. & Basu, Pl. 492A.

HINDI *Chirval*; BENG. & ORIYA—*Surbuli*; TEL.—*Cheriveru*; TAM.—*Chiruver, imburaver, saya-wer*; MAL.—*Chayaver.*

A diffuse, somewhat woody annual or biennial up to 10 in. high occurring from Bihar and Orissa to Travancore. Branches more or less angular and rough; leaves small, often fascicled, sessile, linear, acute; flowers minute, white, in 3–7 flowered umbellate cymes or sometimes axillary; capsules small, globose, didymous.

The leaves and roots are considered expectorant and used in asthma, bronchitis and consumption. A decoction of the leaves is used as a wash for poisonous bites (Kirt. & Basu, II, 1265; Chopra, 494).

The root bark, preferably of two year old plants, is the source of Chay-root dye, once employed with mordants for imparting red colour to calico, wool and silk fabrics. The plant was extensively cultivated on the Coromandel coast. Small quantities of chay-root were

*Supt., Govt. Museum, Madras*

FIG. 12. HEDYOTIS UMBELLATA—ROOTS

also exported to Europe but they did not meet with much favour in foreign countries, probably because the bark deteriorated in the dark and damp holds of ships during transit. The colours obtained by chay-root are similar to those given by madder (from *Rubia tinctorum* Linn.), but the former possesses only about half the dyeing power of madder. The colouring matter is located almost entirely in the bark. Chay-root resembles madder in that both contain alizarin, rubichloric acid and ruberythric acid. There are marked differences in other constituents; purpurin and purpuroxanthin carboxylic acid which are present in madder are almost entirely absent in chay-root. Considerable quantities (c. 1%) of yellow crystalline substances are present in chay-root; they include alizarin α-methylether, acetylalizarin α-methylether, anthragallol dimethylethers, hystazarin monomethylether and *m*-hydroxyanthraquinone (Perkin & Everest, 36–40).

*H. costata* (Roxb.) Kurz syn. *H. vestita* R. Br. is a stout, diffuse herb with lanceolate leaves and axillary

cymes of flowers, occurring in Sikkim and Assam, ascending up to an altitude of 5,000 ft. A decoction of the root is reported to be employed in Malaya as a lotion for rheumatism (Burkill, I, 1130).

*H. diffusa* Willd. syn. *Oldenlandia diffusa* Roxb. is a diffuse annual with linear leaves and usually solitary white flowers, occurring throughout the greater part of India. The powdered herb or its decoction is used for general weakness, biliousness, impure blood, excessive thirst and heat, fever and gonorrhoea. In Philippines, a brew of the plant is used as mouth wash in toothache (Kirt. & Basu, II, 1267; Rama Rao, 205; Fox, loc. cit.).

*H. fruticosa* Linn. syn. *Oldenlandia fruticosa* K. Schum. is a much-branched shrub with narrowly lanceolate leaves and axillary cymes of white flowers, occurring in the hills of Travancore. The wood is slender, straight, white in colour and light. It is much used for temporary fencing of village gardens and in the construction of mud walls. Due to its straightness and regular cylindrical form, it is recommended for use as umbrella handles. A decoction of the leaves of the plant is reported to be used in Ceylon for inflamed eyes (Lewis, 227).

*H. glabra* R. Br. is a diffuse glabrous herb with subsessile, lanceolate, membranous leaves and axillary pedunculate cymes of small flowers, recorded from some parts of Bengal and Assam. A decoction of the herb is used as a blood purifier. In Malaya, the herb is employed in the preparation of poultices for headaches and stomachaches. Mixed with a little ginger and salt it is used for incipient sores (Burkill, I, 1131).

*H. hispida* Retz. syn. *H. verticillata* Lam.; *Oldenlandia hispida* Benth. is a diffuse, scabrid herb with lanceolate or linear leaves and small white flowers, occurring in the outer Himalayas and north-eastern parts of India. A decoction of the herb is given in dysentery. The plant is also employed in the preparation of poultices for headaches and stomachaches (Burkill, I, 1131).

*H. nitida* Wight & Arn. syn. *Oldenlandia nitida* Gamble is a slender prostrate or ascending annual with angular branches, lanceolate leaves and small white or pink flowers, occurring in the south-western parts of the Deccan Peninsula. The leaves are reported to be eaten with rice in Ceylon.

*H. pinifolia* Wall. ex. G. Don is a slender, diffuse, much-branched annual, found in parts of Bihar and the Andaman Islands. The plant is employed in poultices for aching parts of the body in Malaya (Burkill, I, 1131).

*H. stipulata* R. Br. is a slender, decumbent herb with ovate-lanceolate, membranous leaves, occurring almost throughout the Himalayas and the Khasi hills at altitudes of 3,000–8,000 ft. The herb is wrapped in plantain leaf and given to cattle suffering from sores and worms in the skin (Carter & Carter, *Rec. bot. Surv. India*, 1912, **6**, 414).

**HEDYSARUM** Linn. (*Leguminosae*)

D.E.P., IV, 209; Fl. Br. Ind., II, 145; Bailey, 1949, 555.

A genus of perennial herbs or shrubs, distributed in the north temperate regions of the world. About 9 species have been recorded from India, but none of them is of economic importance. One exotic species, *H. coronarium* Linn. (SULLA, FRENCH HONEY SUCKLE, SPANISH SAINFOIN), has been introduced into India and grown in gardens for ornamental purposes.

*H. coronarium* is a small perennial or biennial herb, 2–4 ft. high, with pinnately compound leaves and deep red, fragrant flowers, borne on crowded racemes; pods segmented with a yellow thorny surface turning brown at maturity. The plant thrives well on hills and is propagated by seeds or by layering (Firminger, 634).

Sulla is an important fodder and green manure crop in countries bordering the Mediterranean and in parts of Australia. It is fed green or as hay and is reported to be comparable to red clover in nutritive value. It yields about 40-50 tons of green fodder per acre under irrigation and about 6–16 tons per acre under unirrigated conditions. Sulla has not become popular in India as a fodder or green manure crop (Whyte *et al.*, 278; *Nutr. Abstr. Rev.*, 1946, **16**, 45).

Analysis of sulla hay (from plants in full flower) gave the following values: moisture, 83; crude protein, 2.26; crude fat, 0.38; crude fibre, 5.16; ash, 1.78; and N-free extr., 7.42%. The N-free extract contains galactans and arabans. Vitamin $B_1$ (*c.* 5 i.u./g.) is present in the leaves [*Chem. Abstr.*, 1948, **42**, 3504; Wehmer, I, 548; *Brit. chem. Abstr.*, 1938 (A, III), 596].

**HELIANTHUS** Linn. (*Compositae*)

A small genus of annual or perennial herbs, mostly natives of Central and South America. Numerous natural hybrids exist making the genus very variable and delimitation of species difficult. Some species are grown in India for ornamental purposes. Two of them, *H. annuus* (Common Sunflower) and *H. tube-*

*rosus* (Jerusalem Artichoke) are well known; the former is grown also as an oilseed or fodder crop and the tubers of the latter are edible.

**H. annuus** Linn. COMMON SUNFLOWER
D.E.P., IV, 209.

HINDI, BENG. & GUJ.—*Surajmukhi*; MAR.—*Surajamukha, suryaphul*; TEL.—*Aditya-bhaktichettu*; TAM., KAN. & MAL.—*Suryakanti.*

An annual herb with erect, rough, hairy stem, 2–15 ft. high; leaves 4–12 in. long, alternate, long-stalked, broadly ovate to cordate, coarsely toothed, roughly pubescent on both sides; flower heads usually 3–6 in. wide, but attaining 12–24 in. width under cultivation: flowers single or double, terminal on the main axis and branches: receptacles flat, more frequently dilated and convex: ray florets yellow, surrounding a brown purple centre of disc florets: seeds (achenes) cylindrical, obovoid-compressed, 3/8 in. long and 1/4 in. broad, white, black or striped grey and black; pappus falling early. Sunflower is self-sterile and fertilization is normally effected by insects.

*I.A.R.I., New Delhi. Photo: H. B. Singh*
FIG. 13 HELIANTHUS ANNUUS—CROP

FIG. 14. HELIANTHUS ANNUUS—FRUITING HEAD

*H. annuus* is not known in the wild state. It is considered to have originated from *H. lenticularis* Douglas, a wild plant indigenous to Mexico. *H. annuus* has long been grown as an ornamental plant and both annual and perennial types are found in gardens. A number of forms with single or double flowers, in yellow, golden and red shades have been developed by intensive breeding work. Some well-known horticultural forms are: var. *californicus* Hort.; var. *citrinus* Hort.; var. *globosus-fistulosus* Hort.; and var. *variegatus* Hort. Selections have also been obtained from *H. debilis* Nutt. (syn. *H. cucumerifolius* Torr. & Gray), an annual, short-statured species with shining foliage and strongly bicoloured rays, quite different from those of *H. annuus*. A collarette form resembling collarette *Dahlia* has been obtained from a culture of red sunflower. There are also on record hybrids obtained by crossing annual and perennial species of *Helianthus* (Cockerell, *Amer. Nat.*, 1915, **49**, 609; Bailey, 1947, II, 1446–47; III, 3281; Chittenden, II, 972; Firminger, 474; Gopalaswamiengar, 437; Ross, *Sci. Agric.*, 1938–39, **19**, 372; Watson, *Pap. Mich. Acad. Sci.*, 1929, **9**, 305; Heiser, *Amer. J. Bot.*, 1948, **35**, 815).

Though cultivated mainly as a garden plant, sunflower owes its economic value to its utility as an oilseed or fodder crop. It was tried long ago as an oilseed crop in Caucasus and Ukraine and has now become well established in U.S.S.R. and the Balkans. In recent years, it has gained importance as an oilseed crop in Argentina, U.S.A. and Canada (Table 1). Other countries where it is grown to some extent for oil are China, Turkey, Italy, France, Chile and Uruguay; it is also raised on a small scale in England, eastern and southern Africa and parts of Asia and Australia [Hurt, 135–40; Blackman, *World Crops*, 1951, **3**, 51; Halderman, *Chemurg. Dig.*, 1949, **8**(5), 15; *Vegetable Oils & Oilseeds*, Commonwealth Econ. Comm., 1956, 59].

As a fodder or forage crop, sunflower is fed green or converted into silage. Sunflower silage is popular in U.S.A., Rhodesia, Canada and a few other countries (Hurt, 45).

For cultivation as oilseed or fodder crop, a number of selections of sunflower are known, varying markedly in height of growth, diameter and colour of heads, shape, size, colour and oil content of seeds and suitability for different conditions of soil and climate. They can be divided primarily into three distinct types, viz., giant, semi-dwarf and dwarf. The giant types are 6–14 ft. tall, generally late maturing and bear heads 12–22 inches in diam.; the seeds are large, white or grey with black stripes, but the oil content is rather low. The semi-dwarf types are 4½–6 ft. tall, early maturing, and bear heads 7–9 inches in diam.; the seeds are smaller, black, grey, or striped and the oil content is higher. The dwarf types range from 2 to 4½ ft. in height, are early maturing and bear heads 5½–6½ inches in diam.; the seeds contain a high percentage of oil. Among the important commercial types cultivated in different countries are: *giants*—Russian Giant, Giant White, Manchurian and Grey Stripe; *semi-dwarfs*—Pole Star, Southern Cross, Mars and Jupiter; *dwarfs*—Sunrise, Mennonite, Advance and Arrowhead (Hurt, 49–51, 59–60; Weibel, *Circ. Ill. Univ. agric. Exp. Sta.*, No. 681, 1951).

TABLE 1—ACREAGE AND PRODUCTION OF SUNFLOWER SEED*

| | 1954-55 | |
|---|---|---|
| | Area (1,000 acres) | Production (1,000 tons) |
| U.S.S.R. | 9,600† | 2,500† |
| Argentina | 1,381 | 278 |
| Uruguay | 358 | 67 |
| Turkey | 343 | 118 |
| Yugoslavia | 309 | 123 |
| South Africa | 300† | 46 |
| Chile | 114 | 65 |
| United States | n.a. | 2† |
| Others | 3,160 | 981† |

* *Vegetable Oils & Oilseeds*, Commonwealth Econ. Comm., 1956, Tables 49 & 50. † approximate unofficial estimates. n.a. not available.

Sunflower is grown in India mainly as an ornamental plant. A large number of horticultural types, including those already mentioned, is cultivated. Efforts made to cultivate sunflower as an oilseed or fodder crop have so far proved unsuccessful and nowhere has it become established as an economic crop. Some of the types tried are Giant Russian,

Advance hybrid Mennonite Mars

FIG. 15. HELIANTHUS ANNUUS—SEEDS OF SOME IMPORTANT TYPES

Sunrise, Mennonite and Advance; of these, Mennonite and Advance appear to be promising for oil and Giant Russian for fodder. However, in comparison with oilseeds like groundnut, safflower or niger, which are all well established, sunflower has no marked advantage. In recent years, seeds of commercial types have been obtained from Canada, Australia, U.S.S.R. and Hungary and are being tried in several centres. The results obtained are summarised in Table 2 (Firminger, 474; Gopalaswamiengar, 437; Hooper, *Agric. Ledger*, 1907, No. 1, 1; Read, *Agric. Live-Stk India*, 1933, **3**, 246; *Annu. Rep. Indian cent. Oilseeds Comm., Oilseeds Ser.*, No. 28, 1951, 15: No. 35, 1952, 24; *Sci. Rep. agric. Res. Inst. N. Delhi*, 1948–49, 136; Choudhuri & Banerjee, *Sci. & Cult.*, 1955–56, **21**, 675).

*Climate & Soil*—Sunflower thrives at medium and high elevations in the tropics. It requires a warm climate with moderate rainfall and shows a somewhat wide range of tolerance to wet and dry conditions. It is drought-resistant and can withstand several degrees of frost. It is adapted to a variety of soils and does well on light, rich, calcareous or alluvial soils and does not require any manuring. It does not thrive on acid soils, water-logged lands or steep slopes. In highly fertile soils it tends to grow very tall, lodge or mature late; the yield of seed is also poor due to production of blind seeds in the heads (Hurt, 35, 63; Nicholls & Holland, 575; Weibel, loc. cit.; Hill, *E. Afr. agric. J.*, 1946–47, **12**, 150).

*Culture*—When grown as an oilseed or fodder crop, sunflower usually follows a crop which has been manured. The land is prepared to obtain a fine tilth and seeds are sown broadcast or in drills in the beginning of April; seeds may also be dibbled in. They are generally sown 1–1½ in. deep in rows 2–3½ ft. apart, the spacing between plants in the row being 6–12 in. The seed rate varies according to the type sown. When planting dwarf or semi-dwarf types for oilseed purposes the seed rate ranges from 4 to 6 lb. per acre, while for giant types, the range is 6 to 8 lb. per acre. For green fodder or ensilage purpose, the seed rate is about 36 lb. per acre. Seedlings when 3–4 in. high are thinned out to 12–18 in. apart. Sometimes seeds are sown in nursery beds and transplanted in the field when 4–6 in. high. The field is weeded in the early stages, but once the crop is established (12–18 in. high), no further cultivation is needed. When plants have reached a height of 3–4 ft. the inferior flower heads are removed, leaving only 4–5 on the main stem (Hurt, 53, 80, 81, 77, 78; Read, loc. cit.; Childs, *E. Afr. agric. J.*, 1948–49, **14**, 77; Bailey, 1947, II, 1445; Weibel, loc. cit.).

TABLE 2—PERFORMANCE OF SUNFLOWER TYPES TESTED IN INDIA*

| State | Period of trial | Types | Yield of seed lb./acre | Yield of green matter lb./acre |
|---|---|---|---|---|
| Bombay† | 1916–17 | Russian Mammoth | 1,000 (rabi)<br>1,900 (kharif) | ..<br>.. |
| Mysore | 1925–35 | Giant Russian | up to 1,430 | 5,000–10,000 |
| | 1945 | Pole Star | 676 | 12,100 |
| | 1950 | Mennonite<br>Advance<br>Sunrise | 572<br>756<br>630 | 11,200<br>14,558<br>12,036 |
| West Bengal | 1951 | Giant Russian<br>Sunrise (Inbred)<br>Sunrise<br>Local | 542<br>209<br>172<br>220 | 28,234<br>10,488<br>8,874<br>18,554 |
| Madras | 1924 | n.a. | .. | 10,000–31,700 |
| | 1951–52 (4 seasons) | 13 types including U.S.S.R.—I, U.S.S.R.—II, Lowaszpatiarai, Inogeszemeceii, Maryinaxil, Local | 230–660 | 10,000 |
| Punjab** | 1931 | n.a. | .. | 37,356 |

* Data supplied by Dep. Agric., Bombay, Mysore, West Bengal and Madras. ** Read, *Agric. Live-Stk India*, 1933, **3**, 246; 1936, **6**, 11. † Russian Giant, Mennonite and Sunrise types were tried in 1950; yield figures are not available. n.a. not available.

Attempts have been made to propagate sunflower by grafting on Jerusalem artichoke (*Helianthus tuberosus*). The resulting grafts are reported to be more vigorous and the seeds produced are richer in oil and low in husk content. The progenies of the first, second and third generations combine the vigour of Jerusalem artichoke, with the earliness and productiveness of sunflower; but the capacity of *H. tuberosus* for tuber development is partially or completely lost (*Plant Breed. Abstr.*, 1952, **22,** 276).

Sunflower is an exhausting crop and makes heavy demands on soil minerals. In order to restore the soil, it is advisable to follow sunflower with a leguminous crop like guar, gram and berseem or burn the stalks and spread out the ash as is done in Russia. Manuring with artificial fertilizers is not recommended as it is reported to lower the oil content of the seed (Read, loc. cit.; Hurt, 44, 72).

For ornamental purposes, sunflower is raised from seeds or by vegetative means. In the case of annual types, propagation is done by seeds or cuttings and in the case of perennials by division. Seeds are best sown in masses in beds or borders. Since they are gross feeders and make vigorous growth, they should be thinned out to get well-developed flowers: they also need staking in order to prevent them from falling down (Bailey, II, 1445; Chittenden, II, 971; Gopalaswamiengar, 437).

*Diseases & Pests*—Among the diseases affecting sunflower in India, the following may be mentioned: rust due to *Puccinia helianthi* Schw., stem-rot caused by *Sclerotinia sclerotiorum* (Lib.) Mass., and grey mould due to *Botrytis cinerea* Fr. Many pests feed on sunflower at various stages of growth and cause considerable damage. The more serious among them are: wire worm, cut worm, web worm, aphids, weevil, moths and beetles. Considerable damage is also caused by birds, pigeons, finches, rabbits and hares. Sunflower plant is sometimes attacked by broom-rape (*Orobanche* sp.), a flowering plant parasitic on roots (*Indian J. agric. Sci.*, 1950, **20,** 107; Hurt, 84-96; Weibel, loc. cit.; *Bull. imp. Inst., Lond.*, 1916, **14,** 88; Blackman, *World Crops,* 1951, **3,** 51).

*Harvesting for seed*—The crop comes to maturity in 4–5 months after sowing. It is left in the field until the colour of the back of the head changes from green to yellow and the seeds become loose. The heads are cut before the seeds are quite ripe to avoid loss by shedding, or whole plants may be uprooted and the heads cut off with a sickle, knife or clippers, and exposed face up between rows to dry. When thoroughly dry, the heads are threshed. They are placed on racks or piled, face downwards on floor and beaten with flails; they may be rubbed face downwards over a metal piece fixed in a wooden frame; they may be passed through a modified maize sheller or gently pressed against revolving cylinders studded with nails. Threshed seeds are spread out in a thin layer on a dry airy floor and turned over occasionally until dry, and cleaned from dry florets and other light impurities by winnowing. Dry seeds keep well for a number of years and retain their vitality if stored in a cool dry place. Rapid rise of temperature has been observed in piles of seed, especially if the moisture content exceeds 12% (Hurt, 97–111, 74; Weibel, loc. cit.: *Bull. imp. Inst., Lond.*, 1916, **14,** 88; Elliott, *J. Dep. Agric. W. Aust.*, 1949, **26,** 44).

The yield of seed varies from about 300 lb. to 3,360 lb. per acre depending upon the type cultivated, fertility of the soil, and cultural practices; the average yield reported from different countries is 780-1,340 lb. per acre. In the trial cultivations of Giant Russian sunflower in India, yields up to 1,430 lb. and 1,900 lb. have been obtained in Mysore and Bombay respectively (Hurt, 110; Blackman, loc. cit.; Hill, loc. cit.; Information from Dep. Agric., Mysore & Bombay).

The seeds are used mainly for the extraction of oil. They are also consumed raw, roasted or salted. In U.S.A., roasted kernels are sold in packets like peanuts; only selected large seeds are husked for this purpose. Shelled seeds are ground and the resulting flour used for bread. A coffee substitute is prepared from roasted seeds. Sunflower seeds form a nutritious food for cattle, poultry, hogs and cage birds (Hurt, 39, 42, 43; *Bull. imp. Inst., Lond.*, 1916, **14,** 88; Holland, *Kew Bull.*, 1919, 58; Edlin, 77; *Amer. Agric., U. S. I. S., New Delhi,* No. 51-A-12, 1951, 6; *Madras agric. J.*, 1916, **4,** 20; Weibel, loc. cit.).

Sunflower seed (wt. of 100 seeds, *c.* 6.75 g.) has a hard woody pericarp, the kernel constituting 50–65% of the whole seed. Analyses of seeds from foreign sources gave the following range of values: moisture, 3.3–12.8; protein, 13.5–19.1; fatty oil, 22.2–36.5; N-free extr., 13.3–21.3; fibre, 23.5–32.3; and ash, 2.6–4.1%. Typical of the analytical values for seeds from Hissar are the following: moisture, 3.74; protein, 13.81; fat, 25.11; N-free extr., 25.55; crude fibre, 26.86; and ash, 4.93%. The ash contains: potassium ($K_2O$), 24.9; calcium (CaO), 8.9; phosphorus ($P_2O_5$), 24.0; magnesium (MgO), 10.5; and sulphur ($SO_3$),

9.9%; sodium, silica, iron, aluminium, chlorine, iodine (42 $\mu$g./kg.), manganese, copper and zinc are present. The seeds contain monosaccharides, 0.31; saccharose and other disaccharides, 3.91 and trisaccharides, 0.73%; no starch or dextrins are reported. The seeds also contain (dry basis): lecithin, 0.23%; nuclein, 0.51%; organic acids (including citric, tartaric and chlorogenic acids), 0.56%; cholesterol, 0.15%; and phytin (Hurt, 112; Wehmer, II, 1227; suppl., 100; Read, loc. cit.; Thorpe, XI, 337; Iodine Content of Foods, 116).

The seed kernel contains albumin (15–32%), globulin (46–48%), glutelin (8–19%) and insoluble protein; no alcohol-soluble protein has been reported. The distribution of total nitrogen in the seed is as follows: humin N, 5.73; cystine N, 2.98; arginine N, 16.80; lysine N, 4.86; histidine N, 4.56; mono-amino N, 45.32; non-amino N, 5.27; and amide N, 15.42%. Approximate amino acid composition of the total protein is as follows: arginine, 8.2; histidine, 1.7; lysine, 3.8; tyrosine, 2.6; tryptophan, 1.3; phenylalanine, 5.0; cystine, 1.4; methionine, 3.4; threonine, 4.0; leucine, 6.7; *iso*leucine, 5.7; and valine, 5.3 g./16 g. N. The globulin contains: glycocoll, 2.5; alanine, 4.5; valine, 0.6; leucine, 12.9; serine, 0.2; aspartic acid, 3.2; glutamic acid, 13.0; tyrosine, 2.0; phenylalanine, 4.0; proline, 2.8; cystine, 1.56; tryptophan, 2.54; arginine, 9.1; histidine, 14.29; and lysine, 1.8% (Wehmer, suppl., 100; Winton & Winton, I, 614–15; Block & Bolling, 491; *Chem. Abstr.*, 1951, **45,** 9138; 1934, **28,** 4085).

*Seed oil* -The oil content of the seed ranges from 22 to 36% (av. 28%); the kernel contains 45–55% oil. Intensive selection work in U.S.S.R. has led to the isolation of strains which yield seeds with thin husks and high oil content (av. 40%). The oil is usually extracted in U.S.S.R. and other European countries from dehulled seeds by cold pressing followed by hot pressing in hydraulic presses: the average yield is 22–29% (Eckey, 775; Blackman, loc. cit.; *Vegetable Oils & Oilseeds*, Commonwealth Econ. Comm., 1956, 59).

The expressed oil is of light amber colour with a mild taste and a pleasant flavour; refined oil is pale yellow. Refining losses are low and the oil has good keeping qualities with little tendency for flavour reversion. The characteristics of the oil are: sp. gr.$^{15°}$, 0.922–0.926; sp. gr.$^{25°}$, 0.915–0.919; $n_D^{25°}$, 1.472–1.474; $n_D^{40°}$, 1.466–1.468; iod. val., 125–136; sap. val., 188–194; hydroxyl val., 14–16; R.M. val., <0.5; Polenske val., <0.5; unsapon. matter, <1.5%; and titre, 16–20°. A sample of oil expressed in *ghanis* (yield, 15%) from seeds grown in India had the following characteristics after refining: sp. gr.$^{35°}$, 0.9147; $n^{25°}$, 1.4732; iod. val. (Hanus), 111.6; sap. val., 194.7; acid val., 6.44; acet. val., 3.62; Hehner val., 91.6; R.M. val., 0.51; thiocyanogen val., 79.12; titre, 13°; and unsapon. matter, 0.55%. The component fatty acids of the oil were: sat. acids, 10% (myristic, 0.38; palmitic, 4.27; stearic, 5.46); oleic, 49.41; and linoleic, 40.48%. The component glycerides were: palmito-oleolinolein, 14.88; stearo-oleolinolein, 15.63; oleodilinolein, 24.23; and dioleolinolein, 45.26%. The oil contains appreciable quantities of vitamins A, D and E, sterols, squalene and other aliphatic hydrocarbons, terpene and methyl ketones (chiefly methyl nonyl ketone) (Williams, K. A., 405; Eckey, 776; Singh & Kumar, *Proc. Indian Acad. Sci.*, 1947, **26A,** 205; Thorpe, XI, 337; *J. sci. industr. Res.*, 1949, **8,** 294; *Chem. Abstr.*, 1940, **34,** 4932; 1944, **38,** 883; 1947, **41,** 3983).

The phosphatides (0.1–0.2%) present in the oil are lecithin (38.5%) and cephalin (61.5%); they occur in combination with protein and carbohydrates. The component fatty acids of the total phosphatides are: palmitic, 14.7; stearic, 5.1; arachidic, 9.5; oleic, 19.3; linoleic, 45.9; and unsat. $C_{20-22}$, 5.5%. The foots from sunflower seed oil refining may be employed as a commercial source of phosphatides (Wittcoff, 232; Thorpe, XI, 337).

The fatty acid composition of the oil is influenced by the environment in which the seed crop is raised. Varietal factors seem to play little part in determining the composition. The ratio of linoleic acid to oleic acid, rather than the total content of unsaturated acids is affected. Examination of oils from seeds grown in widely different localities revealed that the proportion of linoleic acid varied from 44 to 72% of the total fatty acids; the variation in the concentration of oleic acid was in inverse proportion; the range of variation in iodine value was 113–136. The rate of development of seeds was also a determining factor in the fatty acid composition. Oil extracted from slow-maturing seeds (grown in relatively cool climates) in comparison to that extracted from quick-maturing seeds was rich in linoleic acid and poor in oleic acid (Barker *et al.*, *J. Soc. chem. Ind., Lond.*, 1950, **69,** 16; Barker & Hilditch, *J. Sci. Fd Agric.*, 1950, **1,** 118, 140; Bridge *et al.*, ibid., 1951, **2,** 472).

The oil is used as a cooking and salad oil, for the manufacture of margarine, shortening and other edible products, in bakery goods, for packing

sardines, and as a base in certain pharmaceuticals. It is one of the few oils that contain little or no linolenic acid and it can be used with advantage in the manufacture of shortenings of any desired consistency. It is considered equal to olive oil in nutritive value and is sometimes used as an adulterant [Hurt, 39; Allen, II, 206; Halderman, *Chemurg. Dig.*, 1949, **8**(5), 15].

Sunflower seed oil is classed as a semi-drying oil and is employed particularly in blends with linseed and other drying oils in paints and varnishes. It is valued for the non-yellowing and the heat-resisting properties of films produced. A blend containing 30-40% sunflower seed oil and 60-70% linseed oil possesses satisfactory drying properties and gives films which are softer, glossier and more elastic than those of linseed oil alone. Sunflower seed oil is used as lubricant, for lighting purposes and treatment of shoddy in woollen manufacture. It has potential value as fuel in diesel motors. It is a fairly efficient foam destroyer and possesses bactericidal action against many bacteria. Sulphonated sunflower seed oil is suitable for the manufacture of high co-efficient liquid disinfectants (Chatfield, 51; Remington, 53; Halderman, loc. cit.; *Chem. Abstr.*, 1948, **42,** 8492; Weibel, loc. cit.; Hurt, 42; *Chem. Abstr.*, 1944, **38,** 467; 1938, **32,** 7605; 1948, **42,** 3457).

*Seed cake or meal*—The cake or meal left after the extraction of oil is used as a high grade protein supplement (Table 3) for livestock, specially dairy cows and poultry. When fed to dairy cows in large amounts, the butter obtained tends to be soft. Pigs fed on the seed cake give soft pork. Undecorticated seed cake contains an undesirably high percentage of fibre. Cake from decorticated seeds is considered equal in feeding value to common seed cakes. It is an excellent source of calcium, thiamine and niacin. The protein of the meal is of high biological value (64%) and digestibility (94%). The amino acids present in the defatted meal are: arginine, 5.46; histidine, 1.43; leucine, 3.71; isoleucine, 2.78; lysine, 1.45; methionine, 1.61; phenylalanine, 2.39; threonine, 1.64; tryptophan, 1.14; and valine, 2.7%. The protein is rather low in lysine [Morrison, 503; *Chemurg. Dig.*, 1948, **7**(9), 15; Thorpe, XI, 337].

Flour prepared from sunflower seed meal is a light grey palatable powder of high nutritive value. It may be used with white wheat flour (up to 20%) in the preparation of bakery goods (Day & Levin, *Science*, 1945, **101,** 438; *Chem. Abstr.*, 1949, **43,** 9183).

*Hulls*—The hulls constituting nearly 33-55% of the seeds, are utilised mainly as fillers in feed cakes and meals. They may be used as fuel and the ash which is rich in potash ($K_2O$, 23.7%) may be used as a fertilizer or for the recovery of potassium carbonate. The hulls are also employed as a bedding material for cattle and poultry. With the aid of suitable binders, they may be used for heat insulating boards and road surfacing material. They find use also in the preparation of polishing abrasives. Other suggested uses include paper pulp and wall board manufacture and furfural production; hull

TABLE 3—COMPOSITION AND NUTRITIVE VALUE OF SUNFLOWER PRODUCTS

| | Dry matter % | Protein % | Fat % | Carbohydrates % | Fibre % | Ash % | Digestible proteins % | Nutritive ratio | Starch equiv. per 100 lb. |
|---|---|---|---|---|---|---|---|---|---|
| Seed[1] | 92.5 | 14.2 | 32.3 | 14.5 | 28.1 | 3.4 | 12.8 | 8 | 103.8 |
| Seed cake[1] (decorticated) | 90.4 | 37.4 | 13.8 | 20.4 | 12.1 | 6.7 | 33.6 | 1 | 72.5 |
| Seed cake[1] (undecorticated) | 92.9 | 19.1 | 7.4 | 28.9 | 30.0 | 7.5 | 17.2 | 2 | 49.5 |
| Hulls[2] | 89.55 | 4.21 | 0.21 | 30.94 | 52.41 | 1.78 | .. | .. | .. |
| Deseeded heads[2] | 88.27 | 8.86 | 3.18 | 46.42 | 18.19 | 11.62 | .. | 6.0 | .. |
| Head meal[2] | 86.0 | 8.84 | 5.86 | 29.70 | 31.70 | 9.90 | .. | 8.5 | .. |
| Petal and floret meal[2] | 86.52 | 10.50 | 6.41 | 35.30 | 24.53 | 9.78 | .. | .. | .. |
| Leaves[2] | 21.24 | 4.12 | 0.70 | 10.53 | 1.97 | 3.95 | .. | 29 | .. |
| Whole plant[3] | 16.9 | 1.4 | 0.70 | 7.9 | 5.2 | 1.7 | 0.8 | 12.3 | .. |
| Silage[1] | 22.2 | 2.1 | 1.0 | 10.0 | 6.8 | 2.3 | 1.1 | 10 | 9.8 |

[1] Woodman, *Bull. Minist. Agric., Lond.*, No. 124, 1945, 7, 12, 14. [2] Hurt, 141–45. [3] Morrison, 1034.

contains: cellulose, 34.6; pentosans, 28.6; crude protein, 4.8; and lignin, 26.9%. Hydrolysis with sulphuric acid (3.5%) yields *c.* 26% reducing sugars; the residue left after the separation of furfural may be briquetted and used as fuel. Dry distillation of hulls (distillate, 43–45%) yields the following products (dry basis): residual tar, 6.9; soluble tar, 2.64; gases, 34.9; methyl alcohol, 1.17; acetone, 0.15; total acids, 4.38; formic acid, 0.39; and residue (carbon), 34.2%; methyl furfural (0.24–0.76%) is present in the liquid distillate (Hurt, 44; Halderman, loc. cit.; *J. sci. industr. Res.*, 1957, **16A,** 246; *Chem. Abstr.*, 1949, **43,** 8709; 1944, **38,** 1064, 5023; 1935, **29,** 4104; 1933, **27,** 6004; 1941, **35,** 6691; 1933, **27,** 3352).

*Heads*—The residual material from heads after threshing out the seeds is used as feedstuff for cattle. It is considered equal to wheat bran in feeding value and relished by stock when fed in mixture with succulents or maize. The compositions of deseeded heads, head meal and residual petal and florets meal are given in Table 3. Fresh deseeded heads may be silaged with or without molasses and dry heads may be composted (Hurt, 133–34; Childs, *E. Afr. agric. J.*, 1948–49, **14,** 77).

The discs of heads are eaten like Jerusalem artichoke. The flower head (receptacle) is a rich source of pectin (pectin content, 23%). Optimum yields of pectin are obtained by extraction at 100° for 45 minutes (initial *p*H, 1.5 or final *p*H, 1.75). The pectin possesses good jellying power equal to that of commercial apple pectin (Burkill, I, 1132; Kertesz, 322; *J. Sci. Fd Agric.*, 1955, **6,** 258*i*).

*Stalks*—The stalks from which heads have been removed are utilised as fuel and the ash used as fertilizer. In Russia, potash is recovered from the ash obtained by burning the stalks (yield of $K_2CO_3$, 40–50 lb./acre). The stalks are used as green manure and are also composted. Analysis of ash from stalks with leaves and deseeded heads gave the following values: phosphorus ($P_2O_5$), 0.98; potash ($K_2O$), 28.90; and lime (CaO), 12.0% (Hurt, 44; Hill, *E. Afr. agric. J.*, 1946–47, **12,** 140; Timson, *Rhod. agric. J.*, 1928, **25,** 281).

The stalks have a high cellulose content and attempts have been made to utilise them for the manufacture of paper and plastics. The paper obtained from whole stalks is of inferior quality, but when freed from pith, the stalks yield a better grade paper. The stalks from which the pith has been separated contain (dry basis): cellulose, 34.4; hemicelluloses, 37.3; lignin, 23.6; and ash, 4.7%. A yield of 40–43% pulp is obtained in sulphite digestion of pith-free stalks. The fibres of the stalk may be separated and used as a filling material for upholstery. The pith is very light (sp. gr., 0.03–0.09) and contains 29.3% uronic acid. It is inferior to sola pith for making hats and helmets (Hurt, 45, 155; *Chem. Abstr.*, 1948, **42,** 9164, 9198; 1943, **37,** 3598; Burkill, I, 1132; Edlin, 77).

The utilisation of sunflower as a fodder or silage crop has proved somewhat successful in parts of India. It is quick-growing and crops can be raised throughout the year by successive sowings. It yields a large bulk of green fodder when cut at the flowering stage (Table 2) (Yegna Narayan Aiyer, 1950, 42; Read, *Agric. Live-Stk India,* 1933, **3,** 246; 1936, **6,** 11; Saxena, *Allahabad Fmr,* 1951, **25,** 5; Hurt, 74, 75).

Sunflower may be fed green or converted into silage. Leaves may be mixed with bran and given to cattle, horses and poultry. The chemical composition and nutritive value of leaves, whole plant and silage are given in Table 3. The plant attains its highest feeding value at the dough stage. Analysis of the whole plant, grown at Lyallpur and cut at the dough stage (moisture, 79.06%) gave the following values (dry basis): protein, 11.94; fat, 3.44; N-free extr., 45.26; fibre, 23.98; and ash, 15.38 g./100 g.; *mineral matter*—$P_2O_5$, 0.505; CaO, 2.460; $Na_2O$, 0.096; $K_2O$, 4.23; MgO, 1.220; $Mn_3O_4$, 0.01; $Al_2O_3$, 0.378; $Fe_2O_3$, 0.181; $SO_4$, 0.251; and insol. residue, 3.51 g./100 g.; iodine, 20.6 μg./100 g.; *digestible nutrients*—dry matter, 11.28; protein, 1.79; fat, 0.32; N-free extr., 6.72; fibre, 1.02; ash, 1.44; and starch equiv., 8.51 lb./100 lb.; *nutritive ratio*, 4.8. Feeding trials showed that at the dough stage, sunflower constitutes a maintenance ration for heifers and compares favourably with leguminous fodders. The digestibility co-efficient of the crude fibre is, however, low (20.2%) because of the very high lignin content (Hurt, 45; Lander & Dharmani, *Indian J. vet. Sci.*, 1936, **6,** 117; Singh, ibid., 1943, **13,** 168).

Sunflower plant is used mostly after ensilaging either alone or with maize, juar or Napier grass. The silage is palatable, succulent and relished by all types of stock. Feeding trials on milch cows have shown that sunflower silage is almost equal to corn silage for the maintenance of weight and yield of milk and butter fat (Hurt, 45; Yegna Narayan Aiyer, 1950, 42; Henderson & Gifford, *Bull. W. Va agric. Exp. Sta.*, No. 210, 1927).

The flowers are a good source of honey. They furnish a yellow dye. The colouring materials present

in the flower are $\beta$-carotene, cryptoxanthin, taraxanthin, lutein and quercimeritrin. Helisterol ($C_{26}H_{44}O_2$; m.p., 242°) and a monovalent sterol ($C_{30}H_{50}O_2$; m.p., 217°) have been isolated from petals (Hurt, 43; U.S.D., 1955, 1711; Wehmer, II, 1226; suppl., 100; *Chem. Abstr.*, 1937, **31**, 6248).

The plant contains a saponin. Ascorbic acid (92.2–156.3 mg./100 g. fresh wt.), carotene (0.111%, dry wt.), citric and malic acids (1.0 mg./g., fresh wt.) and small amounts of malonic, lactic, succinic, aconitic and fumaric acids are present in the leaves. Leaf extracts show antibacterial properties (*Chem. Abstr.*, 1952, **46**, 10548; 1953, **47**, 12538; 1950, **44**, 696; Wehmer, suppl., 100; Bentley, *Nature, Lond.*, 1952, **170**, 847).

Sunflower seeds are diuretic and expectorant. They have been used in bronchial, laryngeal and pulmonary affections, coughs and cold. In Russia, medicinal properties similar to those of the oil are attributed to them. In China, the seeds are administered in dysentery. A tincture of flowers and leaves is recommended, in combination with balsams, for bronchiectasia. Leaves are reported to be employed in the treatment of malarial fevers in Caucasus (Kirt. & Basu, II, 1370; Caius, *J. Bombay nat. Hist. Soc.*, 1939-40, **41**, 845; Wren, 340; U.S.D., 1955, 1711).

**H. tuberosus** Linn. JERUSALEM ARTICHOKE, GIRASOLE, TOPINAMBUR.

D.E.P., IV, 211; Bailey, 1947, I, 401, Fig. 391; II, 1449.

HINDI—*Hatichuk*; BENG.—*Brahmokha*.

PUNJAB *Hathipich*.

An erect, hardy, tuberous perennial, native of North America and cultivated for its edible tubers in Europe, parts of Asia and throughout the temperate regions of the southern hemisphere. The plant attains a height of 5–12 ft.; leaves 4–8 in. long, opposite below and alternate above, ovate, acuminate, serrate, rough above and finely pubescent beneath; flower heads few or many, 2–3 in. across with yellow florets; achenes 4-angled, pubescent. The plant is grown in India to a limited extent in gardens and hill stations. It is reported to have been introduced in Assam, Bengal, U.P., Bombay, Baroda and Hyderabad. It thrives best at an elevation of 1,000–2,500 ft., but can be grown up to 4,000 ft. (Thompson, 210; Gollan, 13; Gopalaswamiengar, 531; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 91).

Though a perennial, *H. tuberosus* is treated as an annual under cultivation. Numerous types are in cultivation, but none of them appears to be well defined. The tubers, which resemble potatoes, but with large eyes, are ovoid, 4–8 in. long and 1–3 in. across, white, yellow, pink, red or purple. Two types have been recorded in Malaya—one with red skin and the other with white skin; a new type bearing tubers which are less knobbly than those of other types, has been recently selected from the white-skinned type. *H. tuberosus* var. *fusiformis*, a newly evolved type grown in France, bears long, fusiform tubers which are reported to have good flavour and palatability (Barrett, 132; Burkill, I, 1133; Chittenden, II, 973; I, 185).

Jerusalem artichoke grows under a wide range of climatic and soil conditions. It grows and produces a profitable crop even on land unsuitable for many other vegetable crops. It is well adapted to rich sandy or light loams and alluvial soils, but does not thrive in wet and heavy soils. If grown in sandy soils, the digging of tubers is easier. Soils suited for potatoes or maize are also suitable for artichoke (Purewal, 57; Thompson, 210; Boswell, *Leafl. U.S. Dep. Agric.*, No. 116, 1936).

*I.A.R.I., New Delhi. Photo: H. B. Singh*

FIG. 16. HELIANTHUS TUBEROSUS—TUBERS

The plant is propagated by tubers or sets. The soil should be well prepared by ploughing and liberally manured (c. 16 cart loads of farmyard manure per acre). Whole tubers or tuber pieces with 2–3 eye buds and each weighing c. 2 oz. are planted about 3 in. deep and 1–1½ ft. apart in rows, the spacing between rows being 2–3 ft. The planting is done during March-May in the plains and from middle of February to middle of April in the hills. About 6 md. of sets are required to plant an acre. Irrigation may be necessary once a week during the dry weather. In the early stages after planting the field is given one or two weedings; no cultivation is necessary after the plants grow up. Earthing up is necessary, as in the case of potato crops, when seedlings are about 1 ft. high. Flowers are picked off as they appear (Gollan, 13; Purewal, 57; Thompson, 210; Gopalaswamiengar, 531).

The crop takes 4–6 months from planting to mature. The tubers are ready for harvesting when the leaves wither and the stems commence to die down. It is advisable to leave the tubers in the soil until required, as they preserve their delicacy and flavour better when left undisturbed. The yield of tubers varies from 5–10 tons per acre; yields as high as 15–16 tons have been recorded under very favourable conditions (Gopalaswamiengar, 531; Purewal, 57; Gollan, 13; Thompson, 211; Boswell, loc. cit.).

The tubers do not develop a thick corky layer as is the case with potatoes. Consequently the tubers shrivel up on exposure and cannot be kept for more than a few weeks except under cold storage (31–32°F.) and high humidity (90–95%) (Thompson, 211; Jacobs, III, 1830; Boswell, loc. cit.).

The tubers may be eaten raw or boiled; they are also pickled, made into chips or ground into flour. They are considered equal to potatoes in food value, though digestive troubles have been occasionally reported. Analysis of tubers gave the following values: moisture, 71.6–84.2; protein, 0.9–3.25; fat, 0.11–0.44; N-free extr., 13.6–18.8; crude fibre, 0.3–3.0; and ash, 0.85–2.5%. The mineral constituents reported are phosphorus (0.099%), calcium (0.023%), iron (3.4 mg./100 g.), sodium, potassium, magnesium, aluminium, zinc, chlorine, iodine (12 μg./kg.), and sulphur. Small amounts of vitamins $B_1$ and C, purine bases, arginine, histidine, betaine, choline and haemagglutinin are present. The enzymes present are inulase (optimum temp., 55–60°), catalase, phosphatase, phenolase and polyphenolase (Gollan, 13; Knott, 277; Bailey, 1947, I, 401; *Food Sci. Abstr.*, 1952, **24,** 370; Wehmer, II, 1224; Winton & Winton, II, 175; Jacobs, II, 1340; Iodine Content of Foods, 77; *Chem. Abstr.*, 1938, **32,** 1804; 1939, **33,** 1054).

The carbohydrate content varies from 8 to 18%, depending on the type, size and shape of the tuber. Besides glucose and levulose, a whole series of glucofructosans, from sucrose to inulin, are present. Inulin and closely related inulides are the principal carbohydrates of the tuber; dilevan, inulenin, helianthin and synanthrin have been isolated. Dilevan is probably a degradation product of synanthrin and is not ordinarily present in fresh tubers. The concentration of inulin is optimum at the time of full maturity (autumn); the concentration of inulides increases during storage at the expense of inulin through the action of inulase (Jacobs, II, 1337–40; *Chem. Abstr.*, 1952, **46,** 3123; 1948, **42,** 6957; *Food Sci. Abstr.*, 1952, **24,** 370).

Jerusalem artichoke has aroused much interest as a commercial source of levulose used as a sweetening agent by diabetics. Improved methods of extraction of inulin have been developed and the possibility of exploiting the tubers for levulose production is indicated. Fresh tubers are sliced and the juice pressed out. The juice is acidified and heated to hydrolyse inulin and inulides. Neutralisation with lime yields calcium levulate which is separated by precipitation and filtration. Carbonation of calcium levulose yields a syrup containing levulose from which the sugar is crystallised out (yield, c. 6% on fresh wt. of tuber). Fructose syrups suitable for use as sweetening agents may be prepared. The tubers may also be utilised for the preparation of industrial alcohol by fermentation (yield, 8–9 l./kg. of tubers) and beer-like beverages (von Loesecke, 319–21; Jacobs, II, 1340; Thorpe, I, 497; *Chem. Abstr.*, 1950, **44,** 3206).

Tubers are used as feed for stock. A rich, palatable feed of good digestibility and comparable to sugar-beet in feeding value is obtained by ensilage. The average nutritive value of the tuber is as follows: digestible protein, 1.2; and total digestible nutrients, 15.9%; nutritive ratio, 12.3 (Morrison, 394, 1018; *Chem. Abstr.*, 1941, **35,** 4866).

Green tops and stems of young plants are used as feed for cattle; they may also be ensiled. The yield of green fodder is 5–9 tons per acre, but the yield of tubers is greatly reduced by the early cutting of tops. The composition and nutritive value of tops is as follows: dry matter, 27.2; protein, 1.4; fat, 0.3; fibre,

4.9 ; N-free extr., 18.5 ; mineral matter, 2.1 ; calcium, 0.44 ; phosphorus, 0.03 ; potassium, 0.37 ; digestible protein, 0.8 ; and total digestible nutrients, 18.1% ; nutritive ratio, 21.6 (Morrison, 394, 1018–19).

The stalks may be treated by the soda-chlorine process to give a pulp (yield of *c.* 20%), which is suitable for the manufacture of certain types of papers (*Chem. Abstr.*, 1951, **45**, 5404).

**HELICIA** Lour. (*Proteaceae*)

Fl. Br. Ind., V, 189.

A genus of trees distributed in tropical Asia, Japan and Australia. About six species occur in India.

*H. erratica* Hook. f. (Nepal—*Bandre* ; Lepcha—*Zheyong-kung* ; Khasi—*Dieng-soh-tyrteit*, *dieng-lingimrit*) is a small to medium-sized tree found in the eastern Himalayas and Assam up to an altitude of 6,000 ft. Bark grey, rough ; leaves variable, elliptic-lanceolate, coriaceous ; flowers yellowish in racemes 3–9 in. long ; fruit an obliquely globose nut, edible. The wood is pinkish grey, moderately hard and heavy (wt., 44 lb./cu. ft.) ; it may be used for inlay work and fancy articles (Gamble, 576 ; Cowan & Cowan, 112).

*H. robusta* (Roxb.) R. Br. ex Wall. syn. *H. javanica* Blume is a medium-sized to large tree, found in Assam up to an altitude of 3,000 ft. Bark brownish ; leaves variable, oblong-lanceolate, serrate, coriaceous ; racemes 9–12 in. long ; fruit an obliquely globose nut. The wood is used for house building. The fruit is poisonous. Very young shoots and leaves are eaten. The plant is used for poulticing (Burkill, I, 1133-34).

**HELICTERES** Linn. (*Sterculiaceae*)

A genus of shrubs and trees found in the warmer parts of the world. Four species are reported to occur in India, of which *H. isora* has attained importance as a source of fibre.

**H. isora** Linn. East Indian Screw Tree

D.E.P., IV, 212 ; C.P., 868 ; Fl. Br. Ind., I, 365.

Sans.—*Avartani, mriga-shinga* ; Hindi & Punjabi—*Marorphali, jonkaphal, bhendu* ; Beng.—*Atmora* ; Mar.—*Kewan, kevani, varkati* ; Guj.—*Murdasing* ; Tel.—*Nuliti, kavanchi, syamali, gubadarra* ; Tam.—*Valampiri, kaiva* ; Kan.—*Yedamuri, kavargi* ; Mal.—*Kaivun, isvarmuri* ; Oriya—*Murmuria, murimuri.*

A sub-deciduous shrub or small tree with stem 1–5 inches in diam. reaching a height of 5–15 ft. Bark grey, in young parts covered with stellate hairs ; leaves obovate or obliquely cordate with serrated margin, scabrous above and pubescent beneath ; flowers solitary or in sparse clusters, 1–2 in. long, with red reflexed petals turning pale blue when old ; fruits 1–2 in. long, greenish brown, beaked, cylindrical, with spirally twisted carpels, which on ripening untwine and scatter the small seeds contained in them.

The plant occurs, often gregariously, throughout India, from Jamuna eastwards to Nepal, Bihar and Bengal and southwards in central, western and southern India and Andaman Islands. It occurs as an undergrowth, especially as a secondary growth in forests. It coppices well, shooting up rapidly when cut or burnt back. In some places, as in the Siwalik tract in U.P., it forms dense, almost impenetrable thickets covering large areas practically to the exclusion of other growth. It is reported to cover an area of over 30,000 acres in Travancore forests. Estimates of coverage in other States are not available (Gamble, 100 ; Troup, I, 162 ; *Jute Bull.*, 1951–52, **14**, 228 ; Sebastine, *Econ. Bot.*, 1954, **8**, 114).

Two varieties of the plant are distinguished, var. *tomentosa* in which the underside of the leaves is glabrous (distributed mostly in northern and central India) and var. *glabrescens* in which both sides of leaves are nearly glabrous (distributed in southern India). The latter variety has been cultivated on an experimental scale in Travancore. It is easily propa-

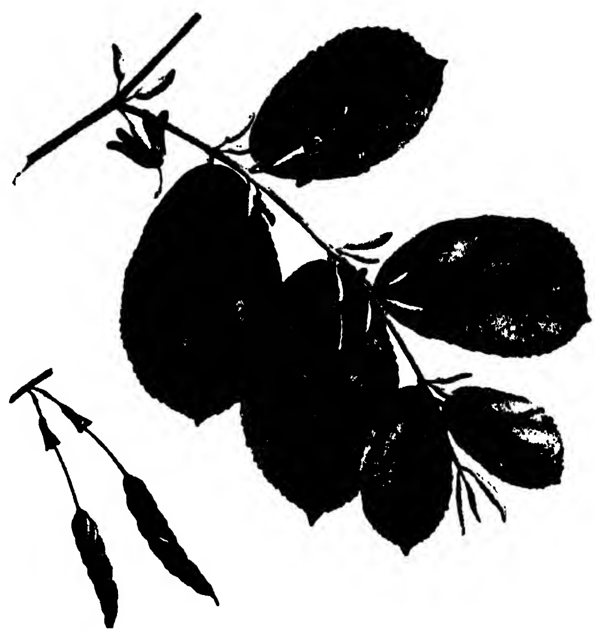


FIG. 17. HELICTERES ISORA—FLOWERING BRANCH & FRUITS

gated by seed sown during the rainy season. It requires a rich humus soil and thrives in places where the rainfall is 120 in. per annum and above and is well distributed throughout the year. In sandy and laterite soils, the growth is stunted and branched and the bark is thin. The plants flower and fruit from the second year onwards; flowers appear during the rainy season from March to September and fruits ripen from December to January. The best type of fibre is obtained when the plants are 1–1½ years old; plants older than 2 years yield coarse and brittle fibre. Stalks can be harvested annually for fibre extraction from regenerated shoots (Sebastine, loc. cit.; Punnoose, *Indian Text. J.*, 1952–53, **63**, 388).

The fibre which is present in the inner bark of the plant is polygonal in cross section with a circular or oval lumen. The fibres are arranged in a reticulate pattern in a series of zones alternating with zones of soft tissue in the phloem region. The cell wall of the fibre elements is thick and lignified. Chemical analysis of the fibre gave the following values: ash, 0.954; cellulose, 74.86; lignin, 23.08; fat & wax, 1.098; nitrogen, 0.291%. The physical characteristics of the fibre are: intrinsic strength, $0.987 \pm 0.054$ g./denier; elongation at break, 5.6%; length of ultimate cells, 1.0 mm.; diameter of ultimate cells, 10.1$\mu$; length to diameter ratio, 99 (Sebastine, loc cit.; Betrabet, *J. sci. industr. Res.*, 1956, **15B**, 671).

The fibre is extracted from the stem by retting in pools, ponds and rivers, as in the case of jute (*Corchorus capsularis*) or sunn hemp (*Crotalaria juncea*). In Travancore, where the kaivun fibre industry was a flourishing cottage industry till the advent of jute, the practice was to collect cut stems (*c.* 1 in. diam.) from forest areas and, after removing the leaves, steep them in water for 18–24 days. Retted stalks were taken out of the water, beaten gently with wooden mallets and the fibres peeled off, washed in water and dried in the sun. Fibre of good colour and quality is obtained when retting is effected in running water.

Data for the production of isora fibre are not available. According to an estimate made in 1951, the yield of fibre is 50–60 md. per acre and *c.* 6,000 md. can be collected in U.P. (Punnoose, loc. cit.; Sebastine, loc. cit.; *Jute Bull.*, 1951–52, **14**, 228).

Isora fibre is light brown to greyish green in colour, soft, silky and lustrous. Combed fibre resembles jute in appearance and varies from 4 to 7 feet in length. It is considered inferior to jute in strength but is more durable. It is used mostly for rough sacking or canvas and as cordage for sewing gunny bags and cattle harness. It is especially valued in Travancore for container bags called locally *Chelavu* and used as pans in lever weighing systems (*Velli-kol*). Bags made of kaivun fibre last more than 5 years, while those made of jute seldom last more than 2 years. It may be used in mixture with jute, to the extent of 40%, for the manufacture of sacking and is considered satisfactory as a second weft.

The quality of fibre is amenable to considerable improvement. By selecting stalks of equal age and maturity, and retting them under proper conditions and scutching the dried fibre on suitable mechanical appliances, it is possible to obtain fibre which can be spun into good yarn and woven into canvas and other durable fabrics of excellent quality. Woven materials can be dyed and printed in attractive designs for making shopping bags. Ropes and cordages made of the fibre are better and smoother than coir products (Punnoose, loc. cit.).

Stalks and twigs of *H. isora*, with or without bark, are suitable for the manufacture of writing and printing paper. The material is available in abundance at low price and can be advantageously employed in paper mills as a supplementary raw material. Analysis gave the following values (oven-dry basis) -*stalks & twigs with bark:* ash, 3.1; cold water extr., 11.5; hot water extr., 12.1; 1% NaOH extr., 27.8; 10% KOH extr., 36.8; ether extr., 4.3; alcohol-benzene extr., 9.7; pentosans, 11.9; lignin, 19.9; and cellulose (Cross & Bevan), 48.3%; *stalks & twigs without bark:* ash, 1.7; cold water extr., 6.2; hot water extr., 6.5; 1% NaOH extr., 19.2; 10% KOH extr., 29.1; ether extr., 0.4; alcohol-benzene extr., 5.6; pentosans, 16.0; lignin, 13.6; and cellulose (Cross & Bevan), 51.4%. Pilot plant trials at the Forest Research Institute, Dehra Dun, have shown that a 35–36% yield of easy-bleaching pulp is obtained by soda or sulphate process from unbarked or barked material. The pulp is short-fibred [*wood fibre:* length, 0.4–1.34 mm. (av., 0.92 mm.); diam. 0.01–0.023 mm. (av., 0.017 mm.); *bark fibre:* length, 0.74–2.36 mm. (av., 1.41 mm.); diam., 0.007–0.023 mm. (av., 0.015 mm.)]. Printing papers may be produced with a furnish consisting of only *H. isora* pulp. For the production of writing papers, however, 40% admixture with long-fibred pulps, such as those of sabai grass or bamboo, is considered essential (Bhat & Singh, *Indian For.*, 1951, **77**, 664).

Leaves and tender branches of the plant are lopped

for fodder. They are reported to be palatable and rich in essential nutrients and pro-vitamin A. Analysis of the leaves gave the following values (dry basis): crude protein, 13.25; ether extr., 3.04; crude fibre, 19.8; N-free extr., 53.02; calcium (CaO), 3.15; and phosphorus ($P_2O_5$), 0.69%. Feeding trials on Kumaoni bullocks gave the following digestibility values (per 100 lb. of dry leaves): digestible crude protein, 9.68; total digestible nutrients, 58.32; and starch equivalent, 46.03 lb.; nutritive ratio, 1:5 (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9; Kehar *et al.*, *Proc. Indian Sci. Congr.*, 1953, pt III, 245).

Dried fruit is reported to be useful in intestinal complaints and prescribed in indigenous systems for colic, flatulence, and diarrhoea. More recently, this drug has been tried in amoebic dysentery, but no material benefit was observed. The drug appears to have no therapeutic properties beyond those of a demulcent and mild astringent (Chopra, 324–25; Kirt. & Basu, I, 371).

The root and stem barks are considered to be expectorant, demulcent, astringent and antigalactagogue. The juice of the root is beneficial in empyema and stomach affections and used in diabetes in Konkan. The bark is prescribed for diarrhoea, dysentery and biliousness. Chemical examination of the bark showed the presence of chloroplast pigments, phytosterol, a hydroxy-carboxylic acid (m.p., 178–79°), an orange-yellow crystalline colouring matter (m.p., 189-90°), saponins, sugars, phlobotannins and lignin (22.4%) (Kirt. & Basu, I, 371; Saraswati Bai, *Bull. Res. Inst., Univ. Travancore*, 1954, **3A,** 89).

The wood is white and soft and used as fuel. The charcoal from this wood is said to be useful for gunpowder (Sebastine, loc. cit.).

**Heliotrope** — *see* **Quartz**

**Heliotrope, Common** — *see* **Heliotropium**

## HELIOTROPIUM Linn. (*Boraginaceae*)

A genus of herbs, rarely shrubs, distributed in the tropical and temperate regions of the world. About 16 species occur in India.

### H. indicum Linn.

D.E.P., IV, 214; Fl. Br. Ind., IV, 152.

SANS.—*Bhurundi, hati-sunda, srihastini, vrischikali*; HINDI—*Hatta-juri, hatta-sura, siriari*; BENG.—*Hati-sura*; MAR.—*Bhurundi*; GUJ.—*Hathi-sundhana, hatisund*; TEL.—*Nagadanti*; TAM.—*Thelkodukupundu, tel-kodukki, nakki-poo*; KAN.—*Chalukondee*; MAL.—*Thekkada, vena-pacha*; ORIYA—*Hati-sura.*

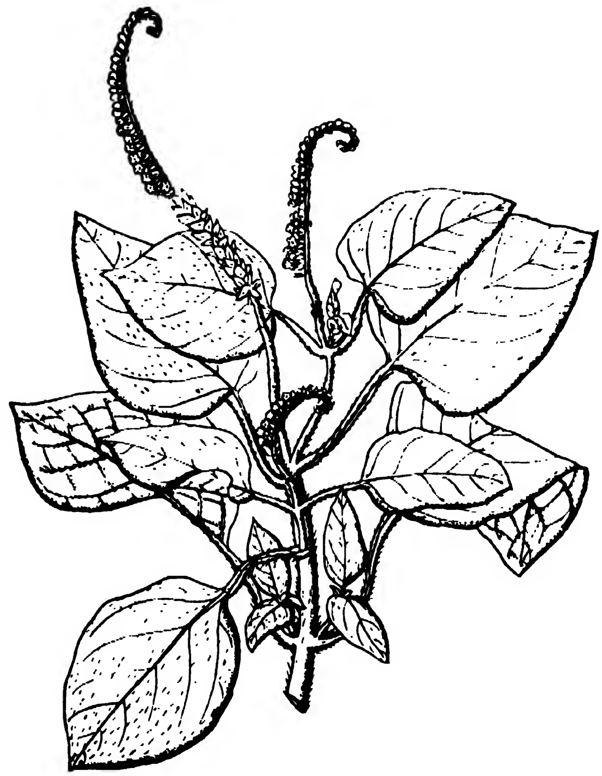


FIG. 18. HELIOTROPIUM INDICUM—FLOWERING BRANCH

M.P.—*Chapputattu.*

A coarse foetid herb, up to 2 ft. high, with ascending hirsute branches, found throughout India. Leaves alternate or sub-opposite, ovate or ovate-oblong, obtuse or sub-acute, serrulate or undulate with cordate, often unequal-sided base; flowers blue or lilac, in bristly scorpioid cymes; fruits deeply bilobed, each lobe 4-ribbed and containing two angular, beaked, hard, 1-seeded nutlets.

The plant is bitter and astringent. Many medicinal uses have been recorded for the plant, but none of them appears to be of importance. It is reported to possess emollient, vulnerary and diuretic properties It is used as local application for ulcers, sores, wounds, gum boils, skin affections, stings of insects and rheumatism; it is also used in poultices. A decoction of tender shoots is reported to be pectoral and antiscabious. A decoction of the leaves is used in fevers and urticaria; that of roots in coughs and fevers. The flowers are considered emmenagogue in small doses and abortifacient in large doses. Seeds are masticated and swallowed as stomachic. The stems and

leaves contain tannin and probably also an alkaloidal principle. The leaves dye an impermanent black (Kirt. & Basu, III, 1690; Burkill, I, 1136; Quisumbing, 777; Brown, III, 228; Dymock, Warden & Hooper, II, 525).

**H. strigosum** Willd. (including *H. brevifolium* Wall. syn. *H. strigosum* var. *brevifolia* C. B. Clarke)

D.E.P., IV, 215; Fl. Br. Ind., IV, 151; Kirt. & Basu, Pl. 651B.

HINDI—*Chitiphul*; MAR.—*Sanjuvanchivel, sitacheres.*

PUNJAB—*Kharai, tindu, gorakh pamo*; RAJASTHAN—*Choti santri*; KONKAN—*Sanjuvanchivel.*

A small strigose procumbent herb with tufted, much-branched, spreading stems occurring throughout India. Leaves small, numerous, linear-lanceolate, acute, with base abruptly contracted into a slender petiole: flowers white, in cymes 1–3 in. long; fruits rounded, depressed, breaking up into four 1-seeded nutlets. *H. brevifolium* bears smaller leaves than *H. strigosum*, which are also whitish and the plant is more common.

The plant is reported to possess laxative and diuretic properties; it is used, sometimes, for pains in the limbs. The juice of the plant is applied to sore eyes; it is also used for boils, wounds and ulcers (Kirt. & Basu, III, 1688). 38, 370

*H. curassavicum* Linn. is a glaucous fleshy herb bearing small white flowers with yellow centres. Probably introduced from West Indies, it is now found along the Coromandel coast. In the south-western desert of America, the roots of the plant are ground to powder and applied to sores and wounds (Krochmal *et al.*, *Econ. Bot.*, 1954, **8**, 3).

*H. eichwaldi* Steud. (PUNJAB—*Bithua, nilkattai, popatbuti*) is an erect, softly hairy annual, up to 2 ft. high, with elliptic-oblong or obovate leaves and cymes of white flowers, found in the plains of north-western India and in Kashmir, up to an altitude of 5,000 ft. The leaves are used in applications for ulcer and warts; they are also used for the relief of earache. The species is suspected to be poisonous. *H. lasiocarpum* Fisch. & Mey., previously considered to be a synonym of *H. eichwaldi*, but now regarded by some as a distinct foreign species, contains the alkaloids heliotrine ($C_{16}H_{27}O_5N$; m.p., 125–26°) and lasiocarpine ($C_{21}H_{33}O_7N$) which appear to be chemically related to the alkaloids of *Senecio* spp. Lasiocarpine causes necrosis of the liver (Kirt. & Basu, III, 1687; Chopra & Badhwar, *Indian J. agric. Sci.*, 1940, **10**, 33; U.S.D., 1947, 1475).

FIG. 19. HELIOTROPIUM OVALIFOLIUM—FLOWERING BRANCH

*H. ovalifolium* Forsk. is an erect or decumbent, softly hairy herb, 6-15 in. high, found almost throughout India. It is said to be poisonous, causing diarrhoea and vomiting. In Africa, it is applied externally to syphilitic ulcers; it is sometimes given internally (Dalziel, 426).

*H. subulatum* Hochst. syn. *H. zeylanicum* C. B. Clarke (Fl. Br. Ind.), non Lam. is an erect, scabrous, hispid annual, found in north-western India and the Deccan Peninsula. In Africa, it is used as a bitter tonic and stimulant (Dalziel, 427).

*H. tuberculosum* Boiss. syn. *H. undulatum* Vahl (PUNJAB—*Jatimisak, pipatbuti*) is an erect, rigid herb, 6–20 in. high, frequently met with in Punjab and Rajasthan. In North Nigeria, it is applied locally for headache and used internally to increase lactation. The herb is also given in gonorrhoea (Dalziel, 426).

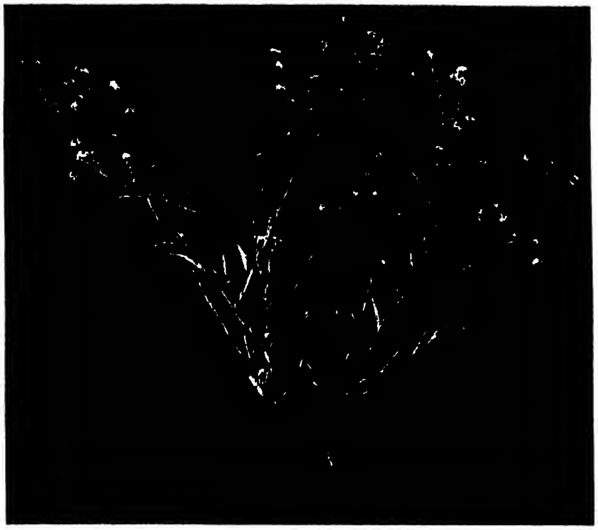


*Photo : M. Sayeeduddin, Hyderabad*

FIG. 20. HELIOTROPIUM SUBULATUM—FLOWERING PLANT

Some of the *Heliotropium* species are cultivated for ornament. *H. arborescens* Linn. syn. *H. peruvianum* Linn. (COMMON HELIOTROPE, CHERRY PIE) is a shrubby plant, native of Peru, grown in Indian gardens. It attains a height of 2–4 ft. and bears clusters of small fragrant flowers, ranging in colour from white to purple, in terminal cymes. It seldom attains a large size when cultivated in the plains, but grows well on hills. Propagation is by cuttings, layering or by seed. The fragrance of the flowers is reported to be due chiefly to the presence of heliotropin and vanillin. The natural perfume is occasionally met with in trade in the form of the absolute; the triple extract obtained by macerating fresh flowers in warm fats, is sometimes used; heliotrope perfumes of commerce are mostly synthetic. The roots contain cynoglossin (Firminger, 440: Chittenden, II, 977; Poucher, II, 126: Wehmer, II, 1017).

**HELMINTHOSTACHYS** Kaulf. (*Ophioglossaceae*)

Beddome, Indian Ferns, 467, Fig. 292.

A monotypic genus of ferns distributed from India to Formosa and New Caledonia.

*H. zeylanica* (Linn.) Hook. syn. *H. dulcis* Kaulf. is a handsome herb occurring in swampy places in the western ghats of South India, up to an altitude of 3,000 ft., and in the north-eastern parts of India. Rhizome thick, fleshy, creeping; stipes up to 1 ft. long; frond divided into two portions: barren segment leafy, palmately divided, often in 3 principal divisions which are stalked and again forked or pinnate, the ultimate division being linear-oblong, acuminate, entire or slightly toothed: fertile spike, 3–4 in. long and ½ in. broad, borne on a firm peduncle arising from the base of the barren segment.

Young fronds (before the expansion of lamina) are eaten either raw or cooked. They contain: moisture, 82.9; nitrogen, 0.475; fat, 0.60; crude fibre, 0.98; and ash, 0.94%; calcium, 47.95; phosphorus, 91.50; iron, 1.79; carotene, 2.105; riboflavin, 0.097; niacin, 0.89; and ascorbic acid, 45.90 mg./100 g. Old stems are reported to be used for matting in Java (Copeland, 13: Burkill, I, 1137; Intengan *et al., Philipp. J. Sci.,* 1955, **84,** 343).

The plant has intoxicating and anodyne properties and is used in sciatica. It is regarded in the Moluccas as a mild aperient. The Malays regard the rhizome as a tonic and eat it with betel for whooping cough: it is used in Java for dysentery, catarrh and early stages of phthisis (Chopra, 495; Kirt. & Basu, IV, 2752; Burkill, I, 1137; Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia,* No. 18, 1953, 9).

**HEMARTHRIA** R. Br. (*Gramineae*)

D.E.P., IV, 218; III, 423; Fl. Br. Ind., VII, 153; Fl. Assam, V, 435; Blatter & McCann, 30, Pl. 21.

A small genus of perennial grasses, distributed in the warmer regions of the Old World. Three species are reported from India.

*H. compressa* (Linn. f.) R. Br. syn. *H. fasciculata* Kunth; *Rottboellia compressa* Linn. f. (HINDI – *Biksa;* BENG.—*Pansheru, buksha;* TEL.—*Shervu panuku;* BOMBAY—*Baika*) is a perennial, polymorphous, hygrophylous grass, with creeping or climbing culms up to 20 ft. in length, found throughout the hotter parts of India, in pasture lands, borders of rice fields, pools and other moist places. It is liked by cattle and esteemed as a moist pasture grass in Africa and Australia. It is propagated in parts of S. Africa by division of roots (Nicholls & Holland, 468).

*H. protensa* Steud. syn. *Rottboellia protensa* Hack. (ASSAM—*Dudh-chaulia, challiya*) is a closely allied grass with culms 3–6 ft. long, found in Assam, Bengal and Khasi hills in marshes, jheels and submerged low lands. It remains alive under water during the monsoon and grows luxuriantly, sending out creepers along the ground when the water recedes during the dry season. It can be propagated by broadcasting runners and rootlets in November or transplanting rootlets in May. It spreads quickly and furnishes good grass for grazing or cutting in areas subject to inundation. A yield of 25,000 lb. of green grass per acre

FIG. 21. HEMARTHRIA COMPRESSA—FRUITING SPIKES

has been reported in Assam. Cattle relish it in all stages and it can be fed either alone or in mixture with other fodders (Das, *Bull. Dep. Agric. Assam*, No. 10, 1939, 2).

**Hematite** — *see* **Iron Ores**

**HEMEROCALLIS** Linn. (*Liliaceae*)

Fl. Br. Ind., VI, 326 ; Blatter, II, 169, Pl. 58, Fig. 4.

A small genus of herbaceous perennials with short rhizomes and numerous fleshy roots, occurring in the temperate regions of Europe and Asia. Popularly known as Day-lilies, some of the species are prized for their hardiness and showy bloom in early hot weather. They are propagated by division of clumps and adapt themselves to all locations, growing in shade or sun and once established, need little attention. They bear abundant foliage and large flowers.

*H. fulva* Linn. (TAWNY DAY-LILY, ORANGE DAY-LILY) occurs in the Himalayas and Khasi hills, and is cultivated in gardens nearly throughout India. *H. aurantiaca* Baker (GOLDEN DAY-LILY) is also known to be under cultivation in Indian gardens. A number of hybrids and horticultural forms of these day-lilies, with flower colours ranging from near white to rose, purple, maroon and variegations, have been developed (Firminger, 317 ; Gopalaswamiengar, 492 ; Percy-Lancaster, 381 ; Stout, *J. N. Y. bot. Gdn*, 1941, **42,** 10, 40).

The flowers of *H. fulva*, as well as of a few other species are a delicacy in China and Japan. The plants are grown in some parts as a crop ; the flowers are harvested, dried and made into bundles, wrapped in paper and sold in Chinese food shops under the name Gum-Tsoy or Gum-Jum. They are used commonly to flavour food. Buds are also used without drying, raw in salad, cooked with meat or in soup, and combined in other ways as a substitute for carrot. Analysis of fresh flowers (from China) gave the following values: water, 85.49 ; protein, 1.66 ; fat, 0.40 ; N-free extr., 10.44 ; fibre, 1.23 ; and ash, 0.78% ; the values reported for dried flowers (from San Francisco) are as follows: water, 15.70 ; protein, 10.11 ; fat, 3.42 ; N-free extr., 58.39 ; reducing sugars, 12.40 ; sucrose, 30.51 ; starch, 5.98 ; fibre, 8.74 ; and ash, 3.64%. They are considered a good source of vitamin A and a fair source of thiamine and vitamin C ; they are also reported to contain adenine (0.07 g./kg.) choline (0.25 g./kg.) and arginine (traces) ; the presence of iodine (420 μg./kg.) has also been reported. The rhizomes contain asparagin (Neal, 161 ; Porterfield, *Econ. Bot.*, 1951, **5,** 3 ; Baker, *J. R. hort. Soc.*, 1937, **62,** 399 ; Burkill, I, 1137 ; Winton & Winton, II, 279 ; Iodine Content of Foods, 23 ; Wehmer, I, 146).

Specific medicinal properties are attributed to the flowers of *H. fulva* in China. Eating the flowers, it is stated, deadens all kinds of pains ; they are given to women in childbirth. An extract of the flowers is used as a blood purifier (Baker, loc. cit.).

**HEMICYCLIA** Wight & Arn. (*Euphorbiaceae*)

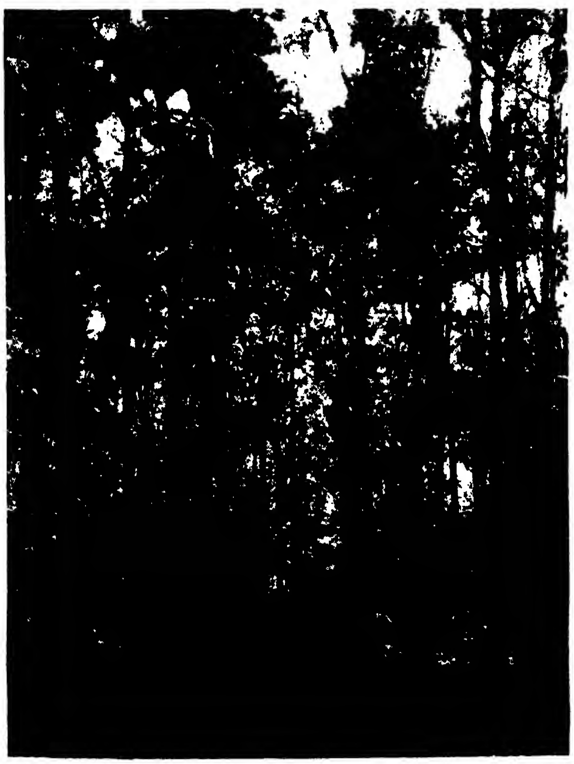
D.E.P., IV, 218 ; Fl. Br. Ind., V, 337.

A small genus of trees and shrubs, now considered by most authors as synonym of *Drypetes,* distributed in south-east Asia and Australia. About 8 species occur in India.

*H. elata* Bedd.=*Drypetes elata* (Bedd.) Pax & Hoffm., *H. porteri* Gamble=*D. porteri* (Gamble) Pax & Hoffm., *H. sepiaria* Wight & Arn.=*D. sepiaria* (Wight & Arn.) Pax & Hoffm. (TEL.—*Bira* ; TAM.—*Virai* ; KAN.—*Hira* ; MAL.—*Vella-kasavu*), *H. travancorica* Bourd.=*D. travancorica* (Bourd.) Jain (TAM.—*Vellei-pillai*), *H. venusta* Thw.=*D. venusta* (Wight)

Pax & Hoffm. and *H. wightii* Hook. f. = *D. wightii* (Hook. f.) Pax & Hoffm. are trees found chiefly in the western ghats; some of them extend eastwards to Carnatic and Circars. *H. andamanica* Kurz = *D. andamanica* (Kurz) Pax & Hoffm. is found in the Andamans.

*H. elata* is a tall tree, attaining a height of 90–100 ft., found in western malnad areas of the Deccan Peninsula; the wood is strong and used for house construction. The wood of this and other species are hard and close-grained and are used locally; that of *H. sepiaria* (wt., 58–67 lb./cu. ft.) resembles box-wood and is useful for turning and axe handles; the wood of *H. porteri* (wt., 61 lb./cu. ft.) is of good quality and used for house posts, rafters, poles, etc.; the wood of *H. travancorica* (wt., 55 lb./cu. ft.) is used for fuel; that of *H. venusta* (wt., 48–51 lb./cu. ft.) is used for house posts, but is not durable; small plants make good walking sticks; that of *H. wightii* is used for posts; the wood of *H. andamanica* gives good charcoal. The fruits of *H. sepiaria* and of *H. andamanica* are edible [Talbot, II, 457–58; Chowdhury & Ghosh, *Indian For. Rec., N. S., Util.*, 1946, **4**(3), 13; Gamble, 605–06; Bourdillon, 289–90; Fl. Madras, 1300; Parkinson, 243].



*F.R.I., Dehra Dun. Photo: H. G. Champion*

FIG. 22. HEMICYCLIA SEPIARIA

## HEMIDESMUS R. Br. (*Asclepiadaceae*)

A monotypic genus comprising the INDIAN SARSAPARILLA, a twining shrub distributed in India and Ceylon.

### H. indicus R. Br. INDIAN SARSAPARILLA

D.E.P., IV, 219; Fl. Br. Ind., IV, 5.

SANS.—*Anantamula, sariva, naga-jihva, gopakanya*; HINDI *Anantamul, kapuri, hindi-salsa, magrabu*; BENG.—*Anantamul*; MAR.—*Anantamul, upalasari*; GUJ.—*Sariva, upalasari, durivel*; TEL.—*Sugandhi-pala, gadisugandhi, muttavapulagamu*; TAM.—*Nannari*; KAN.—*Karibandha, sogade*; MAL.—*Naruninti*; ORIYA—*Onontomulo*.

A slender, laticiferous, twining, sometimes prostrate or semi-erect shrub, occurring over the greater part of India, from the upper Gangetic plain eastwards to Assam and throughout central, western and southern India. Roots woody, aromatic; stems numerous, slender, terete, thickened at the nodes; leaves opposite, short-petioled, very variable, elliptic oblong to linear-lanceolate (1–4 in. × 0.3–1.5 in.), often variegated with white above, sometimes silvery white and pubescent beneath; flowers greenish outside, purplish inside, crowded in subsessile axillary cymes; follicles slender, *c.* 4 in. long, cylindrical, sometimes curved, divaricate; seeds numerous, black, flattened, with a silvery white coma.

The dried Indian sarsaparilla roots are medicinal and constitute the HEMIDESMUS or ANANTAMUL which is official in Indian Pharmacopoeia; they were at one time official also in B.P. The drug comes to the market in small bundles of root pieces, 6 in.–1 ft. long, or as compact bundles of the entire root system of one or more plants tied up with a piece of the stem. The roots are cylindrical, 0.2–0.7 in. or more in thickness, somewhat tortuous, seldom branched, brownish or purplish in colour, with a short fracture at the periphery and fibrous at the centre. The surface of young roots is generally smooth, but in older roots the surface is transversely cracked and longitudinally fissured. The bark has no characteristic taste or odour and is easily separable from the inner tissue surrounding the central wood, which is the officinal part. In the fresh condition the inner cortical tissue is mealy white in colour, but on

FIG. 23. HEMIDESMUS INDICUS—FLOWERING AND FRUITING BRANCHES AND ROOTS

exposure it becomes dark brown; it has a characteristic fragrance and aromatic sweetish taste. The drug, as specified in I.P., should contain not more than 2% foreign organic matter and 4% ash. It should contain alcohol-soluble extractive not less than 15% and water-soluble extractive not less than 13.5%. The drug deteriorates with age and fresh roots are preferred (I.P., 253; *Pharmacognosy of Ayurvedic Drugs of Travancore-Cochin*, Univ. Travancore, Ser. I, 1951, 14; I.P.C., 118).

The drug has long enjoyed a reputation as tonic, alterative, demulcent, diaphoretic, diuretic and blood purifier. It is employed in nutritional disorders, syphilis, chronic rheumatism, gravel and other urinary diseases and skin affections. It is administered in the form of powder, infusion or decoction as syrup. It is also an ingredient of several medicinal preparations. It is used as a substitute for Sarsaparilla (from *Smilax* spp.) and employed as a vehicle for potassium iodide and for purposes for which sarsaparilla is used. A syrup made from the roots is used as a flavouring agent and in the preparation of a sherbet which is reported to have cooling properties.

Air-dried roots yield 0.225% essential oil (sp.gr.$^{30°}$, 0.9553; $n_D^{30°}$, 1.5342) containing *p*-methoxy salicylic aldehyde (m.p., 42°) as the major constituent (*c.* 80%). The aroma of the drug is attributed to this aldehyde. Other constituents present in the roots are: β-sitosterol, α- and β-amyrins (both free and as esters), lupeol, tetracyclic triterpene alcohols, small amounts of resin acids, fatty acids, tannins, saponins, a glycoside and a ketone (m.p., 83–84°) (Dutta *et al.*, *Arch. Pharm. Berl.*, 1938, **276,** 333; *Chem. Abstr.*, 1938, **32,** 8696; Murti & Seshadri, *Proc. Indian Acad. Sci.*, 1941, **31A,** 399; **14A,** 93; Chatterjee & Bhattacharyya, *J. Indian chem. Soc.*, 1955, **32,** 485).

The roots of *Ichnocarpus frutescens* R. Br. (q.v.) are often mixed with and substituted for Indian sarsaparilla. The latter itself is reported to be substituted for Rhatany roots (*Krameria* spp.).

The milky latex of the plant is used, in Travancore, for relieving inflammation in the eye. Ether extract of roots exerts some inhibitory effect on the growth of *Escherichia coli*. The leaves are chewed and are said to be refreshing; narrow-leaved forms which are generally found in open country are preferred for this purpose. The plant yields a fibre (B.P.C., 1934, 505; Kirt. & Basu, III, 1597; I.P.C., 118; Nadkarni, I, 620; Rama Rao, 258; Dastur, Medicinal Plants, 134; Dymock, Warden & Hooper, II, 447; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B,** 261).

**HEMIDICTYUM** Presl (*Polypodiaceae*)

A small genus of ferns found mostly in temperate regions. Two species occur in India.

**H. ceterach** Linn.—*Ceterach officinarum* DC. syn. *Asplenium ceterach* Linn.

Beddome, Indian Ferns, 194, Fig. 95.

A small fern occurring in north-western Himalayas from Kashmir to Garhwal, ascending to an altitude of 9,000 ft. Rhizome short, more or less erect, clothed with dark narrow scales; leaves up to 8 in. long, persistent, tufted; petiole about one-fourth as long as the blade, scaly; blade pinnatifid or scarcely pinnate, lobes alternate, ovate or oblong, coriaceous, upper surface naked, lower surface densely covered with small brownish scales.

The plant is considered diuretic and astringent and it is occasionally used in some parts of Europe for diseases of the urinary tract. The rhizome is used for enlargement of the spleen, incontinence of urine, calculus and jaundice. A plaster made from leaves

and steeped in wine is used as a local application (Caius, *J. Bombay nat. Hist. Soc.*, 1935–36, **38,** 356).

**Hemigyrosa** — *see* **Lepisanthes**

**Hemimorphite** — *see* **Zinc Ores**

**HEMIONITIS** Linn. (*Polypodiaceae*)

Beddome, Indian Ferns, 413; Bailey, 1947, II, 1457.

A small genus of ferns found in the tropics of both hemispheres. *H. arifolia* (Burm.) Moore (MULE FERN: BENG.—*Chakuliya*) is a small tufted fern found commonly in the plains and mountains of S. India, up to nearly 3,000 ft. and in Bengal, Bihar and Orissa. The fronds are 2–3 in. long and equally broad, cordate-hastate, with sori along the veins. The plant is found in dry localities, sometimes growing among crevices in rocks. It is cultivated in gardens and can be easily propagated by spores and by means of young plants found at the base (Blatter & d'Almeida, 180; Haines, VI, 1199; Mooney, 221).

In the Philippines, crushed juice from the fronds is reported to be used for burns (Fox, *Philipp. J. Sci.*, 1952, **81,** 336).

**Hemlock, Poison** — *see* **Conium**

**Hemlock, Spruce** — *see* **Tsuga**

**Hemp, Agrimony** — *see* **Eupatorium**

**Hemp, Ambari** — *see* **Hibiscus**

**Hemp, Bombay** — *see* **Crotalaria**

**Hemp, Bow-string** — *see* **Sansevieria**

**Hemp, Deccan** — *see* **Hibiscus**

**Hemp Drugs** — *see* **Cannabis**

**Hemp Fibre** — *see* **Cannabis**

**Hemp, Indian** — *see* **Crotalaria**

**Hemp, Manila** — *see* **Musa**

**Hemp, Mauritius** — *see* **Furcraea**

**Hempnettle** — *see* **Galeopsis**

**Hemp, Pua** or **Wild** — *see* **Maoutia**

**Hemp, Rajmahal** — *see* **Marsdenia**

**Hemp, Sann** or **Sunn** — *see* **Crotalaria**

**Hemp, Soft** — *see* **Cannabis**

**Hemp, True** — *see* **Cannabis**

**Henbane** — *see* **Hyoscyamus**

**Henna** — *see* **Lawsonia**

**Heptapleurum** — *see* **Schefflera**

**Herabol Myrrh** — *see* **Commiphora**

**HERACLEUM** Linn. (*Umbelliferae*)

D.E.P., IV, 222; Fl. Br. Ind., II, 711.

A genus of herbs distributed in the north temperate region and tropical mountains. About 23 species occur in India. A few of the more common Himalayan species provide winter fodder for goats; some are eaten as vegetable and pot-herb; a few are ornamental.

*H. cachemiricum* C.B. Clarke is a herb, 1–3 ft. high, with radical, pinnately divided leaves and ovoid fruits, ¼ in. × 1/5 in. occurring in the north-western Himalayas at altitudes of 5,000–8,000 ft. The dry fruit contains 0.8% of an essential oil (sp.gr.$^{15}$, 1.0304; $n^{20}$, 1.504) (*Rep. ess. Oils Schimmel*, 1947–48, 82; Chopra, *J. sci. industr. Res.*, 1952, **11A,** 239).

*H. nepalense* D. Don is a small shrub, 2–5 ft. high, with pinnately divided leaves and obovoid fruits, ⅓ in. × ¼ in., frequently met with from Nepal to Bhutan at altitudes of 5,000–12,000 ft.

Four furo-coumarins, viz., bergapten ($C_{12}H_8O_4$; m.p., 188–89°), a substance isomeric with bergapten (m.p., 157–58°), byakangelicin ($C_{17}H_{18}O_7$; m.p., 120–24°) and allo-imperatorin ($C_{16}H_{14}O_4$; m.p., 229°) have been isolated from the ethereal extract of the seeds of *H. nepalense*. Two other crystalline compounds with m.p. 202–204° and 231° have been isolated, but not identified (Bhar, *Sci. & Cult.*, 1946–47, **12,** 504; *J. Indian chem. Soc.*, 1948, **25,** 139).

*H. wallichii* DC. is a herb, 3–4 ft. high, with 3-partite or pinnately divided leaves, found at high altitudes in Nepal and Sikkim. The root is said to be tonic and aphrodisiac (Kirt. & Basu, II, 1223).

**Herb Bennet** — *see* **Geum**

**HERITIERA** Ait. (*Sterculiaceae*)

A small genus of trees found in the tropics of the Old World. Six species occur in India.

**H. littoralis** Dry.

D.E.P., IV, 223; Fl. Br. Ind., I, 363; Brown, I, Pl. 14.

* MAR.—*Sundrichand, kolland*; TEL.—*Adavibadamu*; TAM.—*Chomuntri, kannadi-yilai*; KAN.—*Chandmara*; MAL.—*Mukuram, nakam.*

ANDAMANS—*Mawtda.*

A small to moderate-sized evergreen ornamental tree with thin, often curving buttresses, found in the coastal forests of India and the Andaman Islands.

* *H. littoralis*, owing to its close resemblance with *H. minor* Lam., the true *Sundri* of Sundarbans, is also known as *Sundri* in Bengal.

but nowhere common. Bark grey, longitudinally furrowed; leaves ovate, oblong or elliptic, 5–8 in. × 2–4 in., coriaceous, glabrous, shining above, silvery and scaly beneath; flowers small, orange-coloured, unisexual, in loose tomentose panicles: carpels more or less free, becoming ovoid, woody, keeled in the fruit; seeds *c.* 1 in. long.

The sapwood of *H. littoralis* is pale brown; heartwood light yellowish red to reddish brown, dull, straight- or interlocked-grained and fine-textured, with an odour resembling that of old leather. The wood is hard, tough, heavy (sp. gr., 0.81; wt., 52 lb./cu. ft.), elastic and strong. It is liable to develop end-splits and surface cracks; good results are obtained by careful air and kiln seasoning. The wood is durable both on land and in water, rarely affected by termites, but liable to attack by teredos and borers (Pearson & Brown, I, 158–59; Brown, I, 42; Lewis, 64).

The timber is knotty and twisted and logs sufficiently straight are rare. It is difficult to saw, but machines well and works to a fine surface on a lathe, taking a good finish and polish. It is chiefly employed in building boats, canoes, ships and wharfs. It is also used for bridges, piling, posts, ties, rafters, joists, beams, poles, paving blocks, furniture, hubs, spokes, felloes and axles, levers, tool handles, mallets, etc. It has a high calorific value and is a good fuel wood (Pearson & Brown, I, 159; Brown, I, 44; Burkill, II, 1141).

The seeds are edible. They contain tannin and fatty oil, but no caffeine; an ethereal oil (0.035%) is also reported to be present. The seeds are used as an adulterant for Cola nuts. The kernel forms about 60% of the weight of seed; it contains: crude protein, 11.07; fat, 7.4–8.3; and ash, 2.91%. The composition of the ash is reported to be as follows: $K_2O$, 40.0; $Na_2O$, 1.96; $P_2O_5$, 22.23; MgO, 6.29; $Al_2O_3$, 2.68; CaO, 1.43; Fe, 0.41; Mn, 0.04; $SO_3$, 8.04; and Cl, 1.07%. The kernel fat has the following characteristics: $n_D^{40°}$, 1.4674; sap. val., 197.1; and iod. val., 59.8. Analysis of the shell showed that it contains: crude protein, 10.3; and ash, 2.69%; the ash contains: Fe, 3.1; and Mn, 0.17% (Shivnath Rai, 33; Eckey, 667; Wehmer, II, 776, 1291).

The bark contains 14–15% tannin and is used, in the Philippines, for toughening fishing nets. Fruits and wood contain 12.0 and 13.0% tannin respectively. Twigs are used as tooth brushes and a decoction of the seeds is given for diarrhoea and dysentery (Burkill, I, 1141; Howes, 1953, 279).

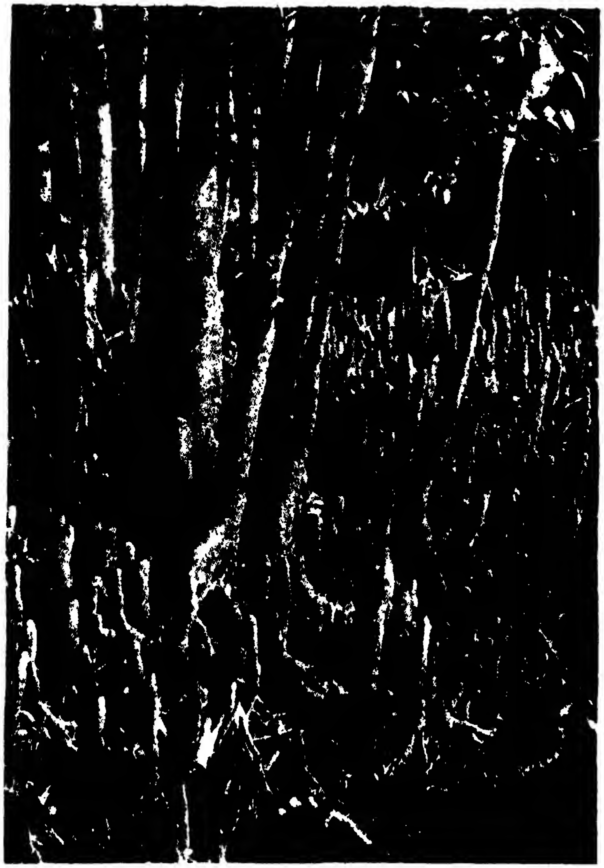
**H. minor** Lam. syn. *H. fomes* Buch.—Ham.
D.E.P., IV, 223; Fl. Br. Ind., I, 363.
BENG. & ORIYA—*Sundri*.
TRADE—*Sundri*.

A small to moderate-sized evergreen tree with grooved and buttressed stem and characteristic pneumatophores, found in the deltaic regions of the Ganges, Brahmaputra and Mahanadi. Bark dark grey with longitudinal fissures; leaves 4–6 in. long, oblong-lanceolate, leathery with silvery scales beneath; flowers small, orange-coloured, unisexual, in tomentose panicles; carpels nearly distinct, becoming woody, furrowed and keeled in the fruit.

Sundri is the characteristic tree of Sundarbans. It grows gregariously and tends to form pure crops with scanty undergrowth. It is found growing in the beach but does not extend far inland; a certain amount of salt appears to be indispensable for its growth, but an excess of it is injurious. Sundri forests fall naturally into fresh water and salt water types; the former

*F.R.I., Dehra Dun. Photo: M. V. Laurie*

FIG. 24. HERITIERA MINOR



F.R.I., Dehra Dun. Photo: M. V. Laurie

FIG. 25. HERITIERA MINOR—PNEUMATOPHORES

type, which is reported to be superior, is met with in the northern and interior parts, whereas the salt water type is found close to the sea and on high ground. The plant avoids low land and land subjected to submergence by high tide; it does not also flourish on high ground, which is often very saline. It is a moderate light demander and requires a warm equable climate with fairly heavy rainfall. The roots do not penetrate very deep, but spread laterally sending up pneumatophores resembling inverted tent pegs. The tree pollards well. Coppice growth requires abundant light and such growth is vigorous in the salt water type.

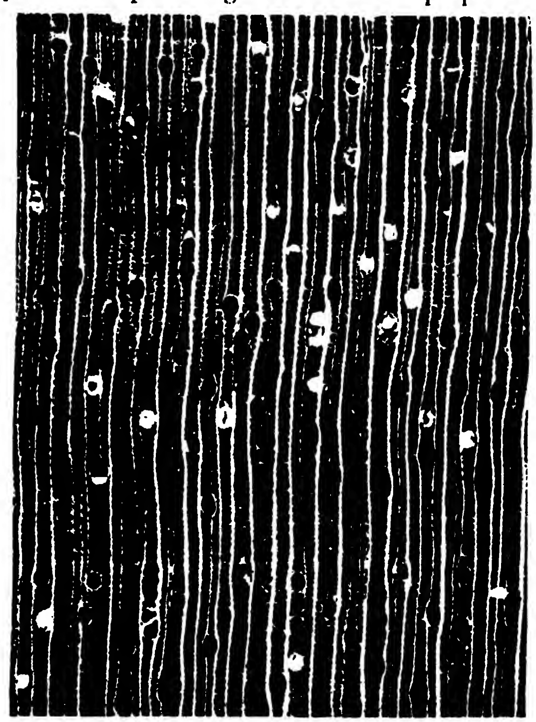
Reproduction takes place by seeds which ripen and fall during the rainy season. Regeneration is more successful under moderate cover. The rate of growth is slow, mean annual girth increment being 0.5 in. Judicious thinning, however, results in considerable acceleration of growth. Sundri is treated under improvement fellings by area combined with thinnings under a felling cycle of 40 years, the exploitable girth being fixed at 3.5 ft. (Bhattacharji, *Indian For.*, 1917, **43**, 21; Troup, I, 153-59).

*H. minor* is reported to be affected by white spongy rot caused by *Hexagonia apiaria* Pers. (*Indian J. agric. Sci.*, 1950, **20**, 107).

The sapwood of sundri is pinkish grey or buff; heartwood dark red to reddish brown, sometimes faintly streaked with black; dull, even- and inter-locked-grained and fine-textured. It is very hard, heavy (sp. gr., 0.84; wt. 58-65 lb./cu. ft.) elastic and strong.

Sundri seasons well, but is prone to fine surface cracking, which can be avoided by low temperature and slow season. Green conversion and drying under cover, with good air circulation, have been recommended. The timber is very durable; untreated posts showed an average life of 18 years in damp localities and 13 years in water-logged soil. Boats built of sundri have been recorded to last 60 years or more. The wood is not attacked by white ants and is more or less immune to marine borers.

The timber, though hard, is not difficult to saw and work to a good finish; it takes a beautiful polish. The data for its comparative suitability as timber, expressed as percentages of the same properties of



F.R.I., Dehra Dun. Photo: K. A. Chowdhury

FIG. 26. HERITIERA MINOR—TRANSVERSE SECTION OF WOOD (× 10)

teak, are: wt., 150; strength as a beam, 110; stiffness as a beam, 130; suitability as a post, 110; shock-resisting ability, 130; retention of shape, 45; shear, 150; and hardness, 175. The calorific value of the wood is: *sapwood*, 5,028 cal., 9,051 B.t.u.; *heartwood*, 5,261 cal., 9,471 B.t.u. It is used as fuel. It yields charcoal of good quality, particularly suitable for gun-powder [Trotter, 1944, 115; Pearson & Brown, I, 155–57; Bhattacharji, loc. cit.; Limaye, *Indian For. Rec.*, *N.S.*, *Util.*, 1944, **3**(5), 18; Krishna & Ramaswami, *Indian For. Bull.*, *N.S.*, No. 79, 1932, 18].

Sundri wood is largely used for boat making, oars, spars, masts, thwarts, carriage building, buggy shafts, felloes, spokes, naves, construction work, posts and beams, piles of bridges, agricultural implements, furniture, etc. It is also used for over-head electric transmission poles, picker arms, tool handles, especially welding hammer shafts, railway keys and brake blocks. The timber is suitable for pulley blocks, tent pegs and pit props (Pearson & Brown, I, 157; Pearson, *Indian For. Bull.*, No. 29, 1915; Trotter, 1944, 116, 194, 227; Limaye, *Indian For. Leafl.*, No. 8, 1941).

The leaves are reported to contain 9.7–11.7% tannin; the leather obtained by the use of leaf tans is of light cream colour with a tendency to redden on exposure and is soft, supple and tough with long fibre. The tannin content of the bark ranges from 8 to 12.4%; the leather obtained by the use of sundri bark is reddish buff in colour, tough but supple, and free from cracks. Both leaf and bark have been recommended for use in the tanning industry; they may be used for the preparation of solid tannin extract. Only barks, which are rich in tannin are commercially useful [Howes, 1953, 279; Das, *Tanner*, 1949–50, **4**(7), 17; 1949–50, **4**(8), 15; Chowdary *et al.*, ibid., 1953–54, **8**(12), 18].

A transparent gum obtained from the bark is used medicinally and also as an adhesive. The leaves are edible. The seeds are starchy and may be used as food in times of scarcity (Bhattacharji, loc. cit.; Shivnath Rai, 33; Burkill, I, 1140).

*H. papilio* Bedd. (TINNEVELLY—*Soundalay unna*) is a tall handsome tree occurring in the evergreen forests of south-western ghats. Its wood is very hard and heavy (wt., 50–63 lb./cu. ft.); it is used for building purposes, cart poles and agricultural implements. *H. acuminata* Wall. (ASSAM—*Arkhar, chingren, thingphelem*) and *H. macrophylla* Wall. (ASSAM—*Tepoppomik, thing-ansil*) are trees occurring in parts of Assam. The wood from these species is hard and useful for posts and ridge plates (Fl. Assam, I, 155–56).

## HERNANDIA Linn. (*Hernandiaceae*)

A genus of trees distributed in the tropics of the world. One species occurs in the Andamans.

**H. ovigera** Linn. syn. *H. peltata* Meissn.

D.E.P., IV, 225; Fl. Br. Ind., V, 188.

An evergreen tree with a spreading crown, commonly found on the shores of Andaman Islands. Bark thick, silvery grey; leaves ovate, 4–9 in. × 3–6 in., truncate or sub-cordate at the base, the long petiole joining the blade within the margin; flowers yellowish white, in involucrate clusters borne at the ends of tomentose panicles, each cluster having two male and a central female flower supported by a cupular involucel; fruit ovoid, *c.* 1 in. long, dark, ribbed, covered by whitish, fleshy, enlarged involucel; seed hard, *c.* ¾ in. diam.

The bark, seeds and young leaves are purgative. The seeds produce dizziness. The root is chewed as a remedy against eating poisonous crabs and fish. The juice of the bark and leaves has depilatory properties (Kirt. & Basu, III, 2165; Lewis, 330; Burkill, I, 1141–42).

The wood is pale grey, soft, light (wt., 20 lb./cu. ft.), but not durable. It is used for temporary work. In some parts of the Pacific, it is used for making canoes which, however, do not last long. The wood catches fire readily and might be used as tinder. The base of the heartwood, which turns black on exposure is used in the Moluccas for the treatment of haemorrhage (Gamble, 575; Lewis, 330; Burkill, I, 1142).

The wood from the trunk yields, on steam-distillation, 1–2% of an ethereal oil with the following characteristics: sp. gr., 0.958–0.963; $[\alpha]_D$, +83.75° to +104.20°; $n_D^{20°}$, 1.4970–1.5011; acid val., 4.4; and ester val., 47.1. The oil contains 75–80% of aldehydes (chiefly dihydrocumic aldehyde) with traces of ester, perhaps cineol. Besides the aldehyde, myrtenal and *d*-limonene are also present (Finnemore, 336; *Chem. Abstr.*, 1916, **10**, 1076).

The wood from the root yields 0.5% of an ethereal oil similar to that obtained from the stem wood. It has the following characteristics: sp. gr., 0.9667; $[\alpha]_D$, +126.25°; $n_D$, 1.5038; it contains 92.5% aldehydes (Wehmer, I, 375; *Chem. Abstr.*, 1916, **10**, 1076).

The ethereal oil from the whole fruit (oil content, 0.5%) has the following characteristics: sp. gr., 0.9528; $[\alpha]_D$, +50.17°; $n_D$, 1.4955. It contains 49%

aldehydes; dihydrocumic aldehyde appears to be absent. The fruit shell contains 0.7% of an alkaloid, probably bebeerin (Parry, I, 164; Wehmer, loc. cit.).

The ethereal oil from the seeds (yield, 1.38%) has the following characteristics: sp. gr., 1.004; $[\alpha]_D$, +87°; $n_D^{20°}$, 1.5061; acid val., 7.3; and ester val., 110.4. The seeds are also reported to contain an alkaloid (Finnemore, 336; Burkill, I, 1141).

The fixed oil of the seed kernel (oil content, 33.9%) is reddish brown with a characteristic odour. It has the following characteristics: sp. gr.$^{15°}$, 0.9380; $n^{27.2}$, 1.47735; acid val., 7.39; sap. val., 195.7; iod. val. (Hubl), 126.1–126.8; ester val., 188.3; R.M. val., 1.77; and Hehner val., 93.17. The mixed fatty acids form a dark green liquid with the following characteristics: neutr. val., 185.7; iod. val., 130.0; mean mol. wt., 302.1; turbidity temperature, 12–13°. They consist of oleic, 39.6; linoleic, 44.6; stearic, 7.1; and palmitic acid, 8.7%. The oil also contains 2% of hernandion (m.p., 167–68° and $[\alpha]_D^{31°}$, −112.4° in chloroform); it possesses feeble drying properties and can be used for the manufacture of soaps, rubber substitutes, and for illuminating purposes. It is reported to be used as a hair restorer and for dandruff in Philippines (Uchida, *J. Soc. chem. Ind., Lond.*, 1916, **35**, 1089; *Chem. Abstr.*, 1947, **41**, 2917; 1953, **47**, 10872; Quisumbing, 329).

**HERNIARIA** Linn. (*Illecebraceae*)

A genus of herbs distributed in Europe, Asia and Africa. One species occurs in India.

**H. hirsuta** Linn.

Fl. Br. Ind., IV, 712.

A small, prostrate, tufted, hairy herb, occurring in Punjab and from Kashmir to Kumaon up to an altitude of 8,000 ft. Leaves small, mostly opposite, ovate or lanceolate, entire; flowers greenish, in axillary clusters; fruits ovoid, 1-seeded.

In South Africa, a decoction of the herb is used for sore throat. The plant also possesses diuretic properties. A decoction of the root is given to horses suffering from bots and colds (Watt & Breyer-Brandwijk, 50).

The herb contains a crystalline principle, herniarin, saponins, and an odoriferous toxic principle, coumarin ($C_9H_6O_2$). Herniarin (m.p., 117–118°) is recognised as 7-methoxy coumarin or methyl umbelliferone and is reported to have been synthesised. Coumarin, in large doses, causes nausea, vomiting, vertigo, depression of the heart and coldness of the extremities. It is said to be powerfully narcotic and irritating to the stomach (Heilbron & Bunbury, II, 650; Watt & Breyer-Brandwijk, 50; Dey *et al.*, *J. Indian chem. Soc.*, 1935, **12**, 140).

*H. glabra* Linn. is a small herb resembling *H. hirsuta*, introduced in Indian gardens for its moss-like foliage forming mats which turn deep bronze red in winter. It thrives in poor soils and may be propagated by seed or by division (Bailey, 1947, II, 1477; Gopalaswamiengar, 171, 195).

The plant is astringent and diuretic. It is generally administered in the form of infusion in catarrhal affections of the bladder. An aqueous extract of the plant is a hand cleanser, making the skin soft and supple (Wren, 300; *Chem. Abstr.*, 1941, **35**, 3032).

The plant contains herniarin and a strongly haemolytic saponin. It also contains an ethereal oil, m.p., 36° (yield, 0.58%) (Wehmer, I, 305; U.S.D., 1947, 1479; Gildemeister & Hoffmann, II, 368).

**Herpestis** — *see* **Bacopa**

**Herrings** — *see* **Fish & Fisheries**

**HESPERETHUSA** M. Roem. *(*Rutaceae*)

A very small genus of small trees or shrubs found in India, Burma, south-western China, Thailand, Indo-China and Ceylon.

**H. crenulata** (Roxb.) M. Roem. syn. *Limonia crenulata* Roxb.; *L. acidissima* auct. non Linn.

D.E.P., IV, 641; Fl. Br. Ind., I, 507; Talbot, I, 198, Fig. 121.

Hindi—*Beli*; Mar.—*Tondsha*; Tel.—*Torelaga*; Tam.—*Nayvila*; Kan.—*Nayibullal*; Mal.—*Kattunarakan*; Oriya—*Bhenta*.

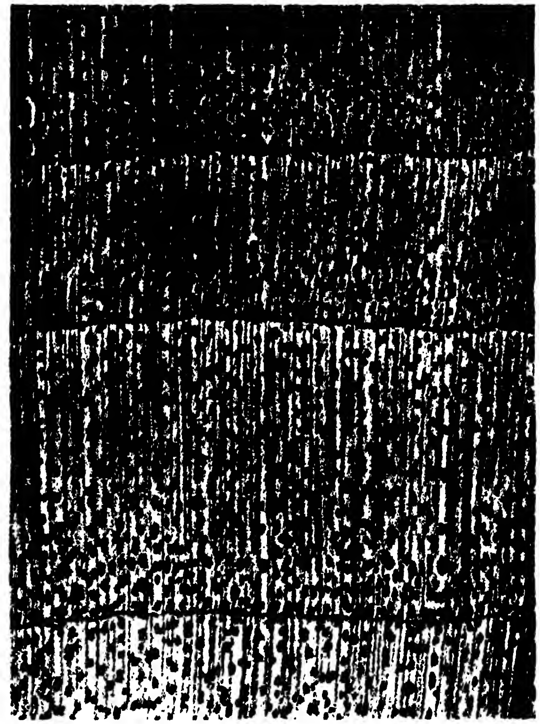
Bombay—*Ran-limbu, naringi*; Chota Nagpur—*Belsian*; Merwara—*Keiri, kara.*

A small straight-stemmed tree, with pale corky bark and thorny branches, reaching a height of 25–30 ft. and a stem diameter of 6–12 in. The tree is handsome with light green foliage. Leaves imparipinnate: leaflets 2–9, sessile, ovate, crenulate; flowers small, white, fragrant, borne in axillary racemes; fruit a small globose berry, black when ripe.

* The genus has been erroneously designated by several authors as *Limonia* Linn., a name which has become a true *nomen ambiguum*, since it was applied right from the time of Linnaeus to two or more distinct plants and later applied to at least 13 diverse genera. In view of its dubious origin and wholesale misuse, it is advisable to reject the name *Limonia* and to use the name *Hesperethusa* M. Roem. (Swingle in Webber & Batchelor, I, 465–66).

The tree occurs nearly throughout India, from Punjab and Kumaon eastwards, in Bihar, Orissa, Assam, Madhya Pradesh, Bombay, Mysore and South India. It grows commonly on dry hills and jungles up to an altitude of 4,000 ft. It can be easily propagated from seed. It has a vigorous root system and may be tried as a root-stock for *Citrus* trees; it can also be grafted on *Citrus*. It flowers during May–June and the fruits ripen in November–December. *Elsinoe* sp., a fungus resembling scab fungi, is reported to attack the fruit (Pearson & Brown, I, 200; Swingle in Webber & Batchelor, I, 300–02).

The wood is hard, heavy (sp. gr., 0.96; wt., 61 lb./cu. ft.), light lemon to brownish yellow in colour, smooth, lustrous, straight-grained and fine-textured; durable and immune to insect and fungus attack; not liable to develop serious end-cracks, but prone to surface cracking; seasons fairly well under shade and can be converted when green; easy to work by machine or hand and finishes to a smooth surface; it has been tested for turnery and on a spindle moulder and found to stand well. The wood is used for axles of carts, oil presses, rice pounders and walking sticks. It may be used as a substitute for boxwood and for tool handles, welding hammer shafts, mallet heads, scales, rulers, beading and inlay work and in cabinet making. It is a good fuel wood. In Burma and Siam, the bark of the wood compounded with sandalwood is ground and used as a cosmetic (Gamble, 128; Pearson & Brown, I, 200–02; Rodger, 52).



*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 28. HESPERETHUSA CRENULATA—TRANSVERSE SECTION OF WOOD (× 10)

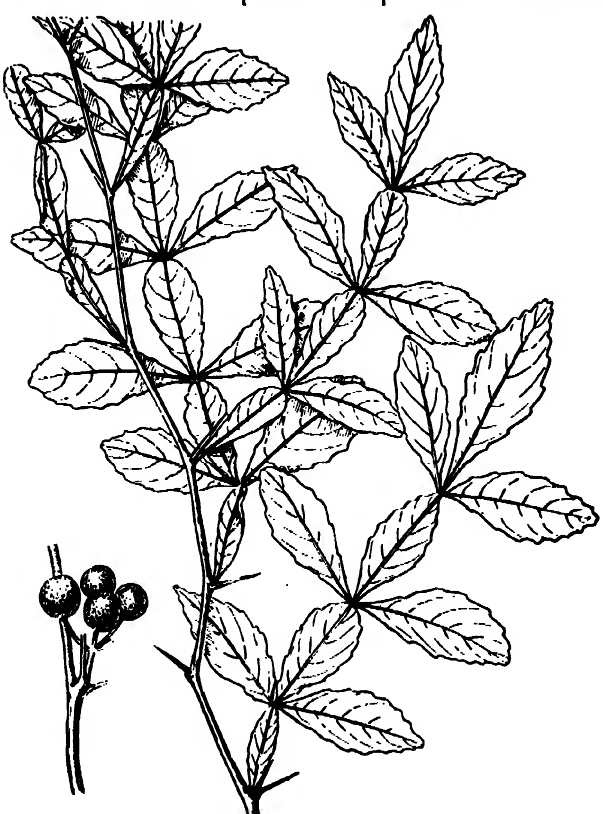


FIG. 27. HESPERETHUSA CRENULATA

The fruit is bitter and occasionally used as a condiment with fish, meat, etc. in India and Arabia. It is used in Java as a substitute for soap. Leaves, fruits and roots are medicinal. The root is yellow, bitter and aromatic and is reported to possess purgative and sudorific properties; dried fruit is tonic and stomachic, and useful in malignant and pestilent fevers, and as an antidote for poisons (Haines, II, 163; Kirt. & Basu, I, 479; Dymock, Warden & Hooper, I, 267).

Another species recorded under the name *Limonia alata* Wight & Arn. and referred to by Alston as *Hesperethusa alata* (Wight & Arn.) Alston, is now considered as *Pleiospermium alatum* (Wight & Arn.) Swingle. This plant occurs in the hot dry forests of South India and Ceylon, and bears small, globose, orange-like fruits, which are bitter. The wood is hard, heavy, yellowish, smooth and even-grained.

If carefully seasoned, it can be used for tool handles. The leaves and bark are used for fomentation in rheumatic pains (Fl. Madras, 157 ; Swingle in Webber & Batchelor, I, 287 ; Lewis, 80 ; Macmillan, 365).

## HESPERIS Linn. (*Cruciferae*)

Bailey, 1947, II, 1479.

A genus of perennial, ornamental herbs distributed in Europe and western and northern Asia. One species *H. matronalis* Linn. (SWEET ROCKET) is cultivated in hill gardens in India.

*H. matronalis* is a perennial herb, 2–3 ft. high, with ovate-lanceolate or lanceolate leaves, 3–4 in. long, and showy, fragrant flowers, ranging in colour from white through lilac and pink to purple, borne in loose racemes. The pods are straight, 2–4 in. long, and contain a number of seeds. The plant can be propagated by seeds, but the popular double forms are multiplied by division or cuttings (Firminger, 622 ; Chittenden, II, 990).

The seeds contain 25–30% of a green (when fresh), odourless, bitter, fatty oil, which is different from most oils derived from cruciferous seeds. It resembles linseed and perilla oils in drying properties and has the following characteristics: sp. gr. $\frac{18^\circ}{4^\circ}$, 0.8892 ; $n_{D}^{70^\circ}$, 1.4646 ; acid val., 1.5 ; sap. val., 192.7 ; iod. val. (Wijs), 190.0 ; thiocyanogen val., 119.8 ; R.M. val., 0.8 ; Pol. val., 0.4 ; and unsapon. matter, 1.7%. The fatty acid composition of the oil is as follows: saturated acids, 8.5 ; oleic, 10.7 ; linoleic, 35.1 ; and linolenic, 45.7% ; the iodine value is considerably higher than that of rapeseed oil ; erucic and other unsaturated acids with more than 18 carbon atoms, which are characteristic of so many seed oils of this family, are not present in the oil (Eckey, 441–42 ; *Chem. Abstr.*, 1943, **37**, 5265).

Saline (0.9% NaCl solution) extracts of the seed agglutinate defibrinated rabbit's blood (Mendel, *Arch. Fisiol.*, **7**, 168).

**Hessonite** — *see* **Garnet**

## HETEROPANAX Seem. (*Araliaceae*)

D.E.P., IV, 226 ; C.P., 1012 ; Fl. Br. Ind., II, 734.

A small genus of unarmed trees distributed in India, Burma, Java, China and Fiji Islands. *H. fragrans* Seem. (HINDI—*Tarla* ; BENG.—*Guti-suna* ; NEPAL—*Lal totilla* ; ASSAM—*Keseru, koronda, karangiya* ; MUNDARI—*Rengebanam*), a small evergreen or deciduous tree, 30–60 ft. high, with large, pinnately decompound leaves and yellow fragrant flowers in umbels, is found throughout the sub-Himalayan tract, from Siwalik eastwards to Bihar, Bengal and Assam and in Andaman Islands. The leaves are used in Assam for feeding eri silkworms as a substitute for castor (*Ricinus communis*) leaves. They are considered to be of medium fodder value. The wood is light brown or grey, rather heavy, close-grained, but very perishable. It is considered to be useful for articles of turnery (Fl. Assam, II, 356 ; Laurie, *Indian For. Leafl.*, No. 82, 1945 ; Gamble, 386).

## HETEROPHRAGMA DC. (*Bignoniaceae*)

A small genus of trees distributed in South-east Asia and Africa. Two species occur in India.

**H. adenophyllum** Seem. = *Haplophragma adenophyllum* (Wall.) P. Dop

D.E.P., IV., 226 ; Fl. Br. Ind., IV, 381.

ASSAM—*Dhopa-paruli, ziron, mostan-phul, lotumpoh.*

TRADE—*Karen wood.*

A handsome tree, 30–50 ft. in height with whitish fissured bark, found in the forests of Assam and the Andamans, and often cultivated in Indian gardens. Leaves large, 2–3 ft. long, pinnate: leaflets elliptic, entire, acute, glabrous above, pubescent beneath ; flowers large, yellowish brown, in terminal panicles ; capsules up to 3 ft. long, cylindrical, curved, 2 valved ; seeds compressed, winged.

FIG. 29. HETEROPHRAGMA ADENOPHYLLUM—FRUITING BRANCHES

The wood is orange yellow with darker streaks, hard, heavy (wt., 53 lb./cu. ft.), elastic and very strong. It is said not to warp or split; its average natural durability according to graveyard tests is about 15 years or more. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak are: wt., 125; strength as a beam, 105; stiffness as a beam, 110; suitability as a post, 120; shock-resisting ability, 115; retention of shape, 65; shear, 125; hardness, 180 [Parkinson, 215; Howard, 247; Bor, 297; Purushotham *et al.*, *Indian For.*, 1953, **79**, 49, Fig. 2/1; Limaye, *Indian For. Rec., N. S., Util.*, 1944, **3**(5), 18].

The wood is suitable for furniture, cabinet work and mouldings. It is also useful for aeroplane work, piles in harbour work, fishing rods, billiard cue butts, and shafts for carts and carriages (Burkill, I, 1143; Pearson & Brown, II, 1070; Howard, 247; Rodger, 132).

**H. quadriloculare** (Roxb.) K. Schum. syn. *H. roxburghii* DC.

D.E.P., IV, 227; Fl. Br. Ind., IV, 381; Talbot, II, Fig. 437.

HINDI & MAR.—*Warras, pullung*; TEL.—*Bondgu, barukoli-gottu, kaligottu*; TAM.—*Baro-kala-goru*; KAN.—*Becadi, adwi-nuggi.*

M.P.—*Ponchia-mara.*

A large tree with grey scaly bark, found in Central India, Saurashtra, northern Circars and the western parts of the Deccan Peninsula. Leaves 1–2 ft. long, pinnate: leaflets ovate, shortly acuminate, entire or serrulate; flowers white or rose-coloured, fragrant, in terminal panicles; capsules slightly compressed, straight, 8–12 in. long.

The wood (sp. gr., *c.* 0.61: wt., 39 lb./cu. ft.) is greyish brown with no distinct heartwood, lustrous when first exposed but becoming dull with age, straight- to interlocked-grained in narrow bands, and medium- and even-textured. It is moderately hard and strong. It is converted green as it is liable to develop end-splits if left in the log. The wood is not considered to be durable and is prone to insect attack. It is easy to saw and works to a somewhat rough surface (Pearson & Brown, II, 768–69).

The wood is suitable for rough planking, rafters, scantlings and posts, but is hardly used except as fuel. It is also stated to be a useful cabinet wood (Pearson & Brown, II, 769; Howard, 247).

A thick fluid-like tar extracted from the wood is said to be used for skin diseases (Kirt. & Basu, III, 1846).

## HETEROPOGON Pers. (*Gramineae*)

A small genus of annual or perennial grasses, distributed in tropical, subtropical and temperate regions of the world. About six species are recorded in India, of which one species is of importance as fodder.

**H. contortus** (Linn.) Beauv. ex Roem. & Schult. syn. *Andropogon contortus* Linn. SPEAR GRASS, BELLARY GRASS

D.E.P., I, 244; III, 423; IV, 227; Fl. Br. Ind., VI, 199; Bor, *Indian For. Rec., N.S., Bot.*, 1940, **2**, 142, Pl. 33.

HINDI—*Kher, kumeria, parwa, sura*; BENG.—*Kher*; MAR.—*Gantegawta*; GUJ.—*Dabhjuliyun*; TEL.—*Eddi gaddi, pandi bella gaddi, kaseri gaddi*; TAM.—*Oosi pullu, pani pullu, karunsi pullu*; KAN.—*Kari vunugada hullu, sunkari hullu*; ORIYA—*Dauria, sinkola.*

PUNJAB *Suryala, sarwala*; BOMBAY -*Sunkhali, kusal, kusali.*

A densely tufted, gregarious, perennial grass, with erect, geniculately ascending culms, 1–5 ft. high and narrow, linear leaves up to 2 ft. long, found chiefly in dry places throughout India ascending up to an elevation of 7,000 ft. in the Himalayas. It occurs in Punjab, Uttar Pradesh, Bihar, Bengal, Assam, Orissa, Madhya Pradesh, Bombay and Madras. It is reported to be the most prominent grass of grasslands at Hosur, where it is grown on about 800 acres annually. Outside India, it is the chief pasture grass in the sub-coastal tracts of Queensland in Australia, where cattle graze on it before flowering. It is a very variable grass and a number of strains differing in growth habit, size and colour of the leaves, pubescence of the inflorescence and time of maturity, are distinguished. A study of their chromosome number reveals the existence of polyploid races (Fl. Madras, 1743; Fl. Assam, V, 402; *Jt Publ. imp. agric. Bur.*, No. 10, 1947, 1; Blatter & McCann, 110; Patwardhan & Hegde, *J. Indian bot. Soc.*, 1927, **6**, 213; Mehra, *Indian J. Genet.*, 1955, **14**, 82).

The grass grows in a wide variety of soils and becomes dominant even on poor rocky and inhospitable lands. It is extremely drought resistant and hardy and often becomes a troublesome weed. Grazing, cutting and even burning do not kill out the perennial underground portions. Even when destroyed by plough, it regenerates slowly. For effective

FIG. 30. HETEROPOGON CONTORTUS—SPIKES & SPIKELET

eradication one or more of the following steps are necessary: (1) ploughing up the existing grass, (2) altering the nature of the soil and especially its water content and (3) introducing competing species (Burns *et al., Mem. Dep. Agric. India, Bot.*, 1925, **14,** 28; 1928, **16,** 101).

The grass can be propagated by seeds or by root stocks; seeds are said to be preferable. About 5–6 lb. of seeds or 5,000–6,000 rootstocks are enough to plant an acre. It tillers profusely under favourable conditions and attains a height of 4 ft. It flowers during August–December and the fruits ripen in October–January. In areas of plentiful rainfall it yields a number of cuttings during the rains. A yield of *c.* 7,380 lb. of green matter per acre per cutting has been recorded at Delhi; two or three such cuttings are possible. In another experiment a total yield of 24,540 lb. of green material has been recorded from seven cuttings. In Izatnagar (U.P.), an average yield of 43,215 lb. of fresh grass per acre has been reported from 3 cuttings, the maximum yield being obtained in the second year during the monsoon. In Hosur, an average yield of 1,100 lb. of hay per acre has been obtained [Saini & Malik, *Indian Fmg*, 1949, **10,** 49; Dabadghao & Gandhi, *Indian J. agric. Sci.*, 1952, **22,** 279; Hosain, *Indian For.*, 1946, **72,** 595; Chaudhary, *Agric. Anim. Husb., Uttar Pradesh*, 1955–56, **6**(10), 4; Nath & Das, *Indian J. vet. Sci.*, 1953, **23,** 185; Ayyangar & Narayanan, *Madras agric. J.*, 1940, **28,** 2].

The grass is one of the chief pasture grasses in the hills of northern India. Cattle avoid it when the fruits ripen, since the sharp, spine-like awns of the fruits become twisted together and cause considerable injury to the gums and buccal mucosa of the animals eating the grass, the injuries becoming sources for other diseases. The seeds cause damage to the general health and condition of wool-bearing sheep by irritating and piercing the skin causing the formation of subcutaneous and in some cases even intramuscular abscesses. It is therefore inadvisable to allow cattle near it at this stage.

The grass, when young, is considered to be a fairly good fodder for cattle, though it is coarse and somewhat fibrous. Many hays made from grasses collected in hills contain a large proportion of this grass. For fodder, the awns should be removed before stacking as hay. A bullock- or horse-drawn comb-shaped rake has been designed for removing awns (Burns *et al.*, loc. cit.; Ayyangar & Narayanan, loc. cit.; Burkill, I, 1143; Steyn, 6; Dalziel, 529; Lander, 151).

For making silage, the grass should be cut with the dew on before flowering and immediately kept in a pit. In Nasik district, a good silage has been made from green grass in a concrete silo, 16½ ft. deep and 14½ ft. wide. From about 23,000 lb. of green grass, 15,755 lb. of silage has been obtained. The silage from young grass is considered excellent in quality and is consumed readily by animals (Ayyangar & Narayanan, loc. cit.; Burns *et al.*, loc. cit.; Warth, *Mem. Dep. Agric. India, Chem.*, 1930, **11,** 53).

The chemical composition (on dry basis) of the grass at different stages of maturity is as follows—*young*: crude protein, 7.52; N-free extr., 49.51; crude fibre, 28.87; ether extr., 3.25; CaO, 0.95; and $P_2O_5$, 0.40%; *pre-flowering*: crude protein, 4.40; N-free extr., 56.83; crude fibre, 26.90; ether extr., 3.17; CaO, 0.46; and $P_2O_5$, 0.32%; *flowering*: crude

protein, 2.35 ; N-free extr., 58.58 ; crude fibre, 28.89 ; ether extr., 2.46 : CaO, 0.34 ; and $P_2O_5$, 0.37%. When young, the grass is fairly rich in protein ; the protein content falls with maturity. The cobalt and copper contents of the young grass are respectively 0.24–0.25 and 10.2–12.0 p.p.m. and adequate for adult cattle maintenance (Dabadghao & Gandhi, loc. cit. ; Datta & Datta Biswas, *Indian J. agric. Sci.*, 1951, **21**, 93).

The mineral and nitrogen contents of the grass vary according to the season and period of growth, the latter being the predominant factor. Under South Indian conditions, the grass shows a deficiency of both calcium and phosphoric acid at all periods of the year and also a rapidly decreasing protein content with the advance of the season. The best period for cutting for making silage or hay is when the grass has flowered and before the seeds have set (Ramiah, *Indian J. vet. Sci.*, 1933, **3**, 65 ; *Mem. Dep. Agric. Madras*, No. 36, 1954, 1207, Lander, *Bull. Indian Coun. agric. Res.*, No. 16, 1942, 44, 48 ; Burns *et al.*, *Bull. Dep. Agric. Bombay*, No. 78, 1916, 4).

Hay from tender grass is of fair quality ; its protein content is comparable with that of silage. Hay prepared from mature grass contains no digestible protein and is unpalatable ; it is somewhat deficient in minerals. Silage produces the same growth as early cut hay, but is more readily eaten and relished by cattle ; it is suitable where abundance of concentrate is fed. Early cut hay is useful when economy of concentrates is desired. Analyses of hay and silage cut at different stages are summarised in Table 1 (Ayyangar & Narayanan, loc. cit. ; Warth, loc. cit.).

The cellulose content of the grass is sufficiently high to warrant its utilisation for paper manufacture. The following is a proximate analysis of the grass (oven-dry basis): moisture, 6.62 ; ash, 7.50 ; solubility in cold water, 10.92 ; solubility in hot water, 15.46 ; solubility in 1% NaOH, 38.30 ; solubility in 10% KOH, 55.60 ; solubility in ether, 1.57 ; solubility in alcohol-benzene, 4.35 ; pentosans, 16.92 ; lignin, 27.30 ; and cellulose (Cross & Bevan), 52.10%. Recent investigations have shown that chemical pulps of satisfactory strength can be prepared by soda and sulphate processes, preferably by the sulphate process, and that the yield and strength of bleached pulp are improved by omitting the intermediate alkali treatment. The pulp obtained being short-fibred requires to be mixed with long-fibred pulps, such as those made from bamboo or sabai grass, for the manufacture of writing and printing paper. Economic utilisation of the grass for pulp manufacture will depend upon its price at the mill site (Bhat & Karnik, *Indian For.*, 1952, **78**, 331).

The culms of the grass are used for thatching ; they are also sometimes woven into mats. The root is stimulant and diuretic and sometimes used in rheumatism (Fl. Madras, 1743 ; Haines, V, 1041 ; Kirt. & Basu, IV, 2685 ; Caius, *J. Bombay nat. Hist. Soc.*, 1935–36, **38**, 561).

## HETEROSPATHE Scheff. (*Palmae*)

Blatter, 410, Pl. LXXV.

A small genus of Malaysian palms, of which one species, *H. elata* Scheff., is cultivated in the Indian gardens for its ornamental, spreading habit. It is a tall, slender palm with pinnatisect leaves, 9–12 ft. long and long pendulous inflorescences, bearing numerous small globose fruits. The palm is easily propagated from seeds. It is worthy of cultivation for its elegant habit and long, tapering leaf segments.

The small, hard seeds of the palm are used in the

TABLE 1—ANALYSIS OF HAY & SILAGE FROM SPEAR GRASS CUT AT DIFFERENT STAGES AT HOSUR*
(on dry matter basis)

| | Crude protein % | Fibre % | N-free extr. % | Ether extr. % | Total ash % | Ash sol. in HCl % | Digestible crude protein per 100 lb. | Total digestible nutrients per 100 lb. | Nutritive ratio |
|---|---|---|---|---|---|---|---|---|---|
| *Hay* | | | | | | | | | |
| Young | 6.97 | 34.52 | 47.94 | 1.35 | 9.22 | 4.27 | 2.93 | 52.97 | 17.1 |
| Prime | 5.30 | 36.89 | 46.89 | 1.19 | 9.73 | 3.50 | 0.84 | 44.77 | 52.4 |
| Ripe | 2.97 | 38.32 | 48.75 | 0.96 | 9.03 | 3.30 | 0.00 | 50.71 | .. |
| *Silage* | | | | | | | | | |
| Young | 6.62 | 36.85 | 43.05 | 1.26 | 12.22 | 5.30 | 1.74 | 50.22 | 27.8 |
| Prime | 6.59 | 32.60 | 43.63 | 1.65 | 15.53 | 5.39 | .. | .. | .. |

* Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 16, 18, 27, 28.

Philippines as a substitute for arecanut (*Areca catechu*). The buds of this as well as of other species of this genus are eaten and the leaflets are used for making sun hats. Splints obtained from the petioles are used for making baskets (Burkill, I, 1143 ; Brown, 1941, I, 308).

**HEVEA** Aubl. (*Euphorbiaceae*)

A small genus of trees distributed chiefly in the Amazon region of South America. One species, *H. brasiliensis*, the source of Para Rubber, has been introduced into India and cultivated as a plantation crop.

**H. brasiliensis** (H.B.K.) Muell. Arg. PARA RUBBER TREE, CAOUTCHOUC TREE

D.E.P., IV, 365 ; C.P., 655 ; Seibert, *Ann. Mo bot. Gdn*, 1947, **34,** 306.

A large tree, attaining a height of 60–100 ft. or more and a girth of 8–12 ft. ; stem smooth and straight, generally unbranched up to a considerable height, with a much-branched leafy canopy ; bark greyish ; leaves trifoliolate with petiole 3.0–4.0 in. long: leaflets glabrous, 4.0–6.0 in. long and 1.5–2.5 in. broad, elliptical-lanceolate, acuminate (tapering at both ends) ; flowers monoecious, small, creamy, yellow or green, sweet-scented, in large pubescent panicles ; fruits ellipsoidal, capsular, tricarpellary, each carpel containing one seed ; seeds ellipsoidal, variable in size, 1.0–1.5 in. long, mottled brown and shining.

*H. brasiliensis* is considered indigenous to the Amazon valley of Brazil, Venezuela, Peru, Ecuador and Colombia. It exhibits large variability in morphological features, habitat preferences, altitudinal range, dry season tolerance, disease resistance, latex yield, rubber quality and other features. Natural hybridisation is considered possible and the great adaptability shown by cultivated types in South-east Asia is attributed to the past introgressive hybridisation between this species and others, particularly *H. guianensis* var. *lutea* (Seibert, loc. cit. ; Dijkman, 17, 254 ; Schultes, *J. Arnold Arbor.*, 1956, **37,** 123).

Prior to the development of the plantation rubber industry in South-east Asia, almost the entire supply of commercial rubber was derived from wild American *Hevea* species. Of the four species tapped for latex in the Amazon basin, viz. *H. brasiliensis*, *H. benthamiana* Muell. Arg., *H. guianensis* Aubl. and *H. guianensis* var. *lutea* Ducke & R. E. Schultes, *H. brasiliensis* is most outstanding owing to its high latex yield and superior rubber quality, and it

*Rubber Bd. India*

FIG. 31. HEVEA BRASILIENSIS—FLOWERING BRANCH

has become the major source of natural rubber in the world market. Hybridisation of *H. brasiliensis* with other species generally results in lowering the rubber quality. However, plantation *Hevea* may be improved by hybridisation with some species, e.g. *H. pauciflora* Muell. Arg. which is resistant to certain diseases and *H. nitida* Muell. Arg. which is xerophytic (Seibert, loc. cit.).

The rubber plantation industry in South-east Asia dates back to 1876, when nearly 1,900 seedlings raised at Kew from 70,000 seeds obtained from Brazil, were despatched to Ceylon. The seedlings became the nucleus, in subsequent years, for the supply of rubber plants and seeds to other countries. Plantations were raised and by 1930 a number of strains had been developed by breeding and selection, some of them far superior to the stock originally obtained from Kew (Wright, 1–2, 8 ; Hutchinson & Melville, 252 ; *World Crops*, 1950, **2,** 75 ; Whaley, *Econ. Bot.*, 1948, **2,** 198 ; Bangham, ibid., 1947, **1,** 210 ; Grist, *World Crops*, 1953, **5,** 175).

The bulk of the world supply of natural rubber is at present obtained from Malaya, Sumatra, Java, Indo-China and Ceylon ; smaller quantities are produced in India, Sarawak, Borneo, Siam, Burma and

equatorial Africa in the eastern hemisphere and in the tropical rain forest region of S. America in the western hemisphere (Table 1). The concentration of rubber industry in South-east Asia is due not only to congenial environmental conditions, such as uniformly high temperatures, well distributed and heavy rainfall throughout the year, and well drained rich forest soils, but also due to the availability of cheap labour.

In India, rubber plantations were first started in Periyar and Poonoor (Kerala State) in 1905. Since then, many other areas have been brought under rubber cultivation. At present, Kerala is the most important rubber producing State in India with plantations concentrated particularly in Kottayam and Quilon districts. Kanyakumari district in the Madras State is also an important rubber growing area; there are small areas in Coimbatore and Nilgiris in Madras State, Coorg in Mysore State and in Andaman Islands. A few acres of old rubber exist in Assam and Bengal but these are in an abandoned condition (Table 2) [*I. & S. Bull.*, 1950, **3**(3), 3: *Indian Rubb. Bd Bull.*, 1951, **1**, 54].

Rubber is produced in India, in plantations ranging from less than one acre to about 3,000 acres in area. Areas above 50 acres are classified as large Estates and those of 50 acres and below, as Holdings. In the beginning of 1957, there were 35,165 holdings (114,294 acres), about 87% of them less than 5 acres in area, and 449 estates (120,057 acres) (Tables 3 & 4).

TABLE 1—ACREAGE & PRODUCTION OF RUBBER IN DIFFERENT COUNTRIES*

| | Area (thousand acres) | | | | Production (thousand tons) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1937-39 (av.) | 1949-52 (av.) | 1953 | 1954 | 1937-39 (av.) | 1949-52 (av.) | 1953 | 1954 | 1955§ |
| Malaya | 3,332 | 3,488 | 3,747 | 2,028†† | 407 | 639 | 574 | 584 | 639 |
| Indonesia** | 1,487 | 1,086 | 1,202 | 1,200 | 383 | 673 | 692 | 739 | 734 |
| Thailand | 339 | 794 | 836 | 840 | 40 | 103† | 96† | 117† | 130 |
| Ceylon | 608 | 656 | 657 | 659 | 61 | 102 | 99 | 94 | 94 |
| Indo-China | 319 | 249 | 197 | .. | 58 | 51 | 75 | 78 | 93 |
| Belgian Congo | 21 | 194 | 190 | 192 | 1 | 12 | 21 | 25 | 28 |
| India | 130 | 171 | 174 | 177 | 14 | 17 | 21 | 21 | 22 |
| British Borneo | 356 | 148 | 119 | 120 | 35 | 66‡ | 42‡ | 41‡ | 61 |
| Burma | 109 | 115 | 115 | .. | 7† | 10† | 10† | 12† | 11 |
| Liberia | 64 | 80 | 83 | 85 | 3 | 32 | 35 | 37 | 38 |
| Others | .. | .. | .. | .. | 20 | 37 | 47 | 43 | 51 |

* *Plantation Crops*, Commonwealth Econ. Comm., 1956, Tables 90 & 91. ** Estates only; figures for 1937–39 are for planted area; from 1949 onwards, for exploited area; production figures are estimated by Rubber Study Group. † Net exports. ‡ North Borneo, Sarawak & Brunei. †† Estates only. § *Rev. Commonwealth Raw Materials*, Vol. 1, Commonwealth Econ. Comm., 1958, Table 77.

TABLE 2—STATE-WISE ACREAGE & PRODUCTION OF RUBBER IN INDIA*

| | Area (acres) | | | Production (tons) | | |
|---|---|---|---|---|---|---|
| | 1954 | 1955 | 1956 | 1954 | 1955 | 1956 |
| Kerala | 163,880 | 193,873 | 219,624 | 19,642 | 20,513 | 21,319 |
| Madras | 8,788 | 9,323 | 10,346 | 1,414 | 1,554 | 1,723 |
| Mysore | 3,648 | 3,713 | 3,900 | 403 | 390 | 367 |
| Andamans | 272 | 272 | 422 | 34 | 24 | 35 |
| Assam | 50 | 50 | 50 | .. | .. | .. |
| West Bengal | 9 | 9 | 9 | .. | .. | .. |
| TOTAL | 176,647 | 207,240 | 234,351 | 21,493 | 22,481 | 23,444 |

* Data supplied by Rubber Board, India.

### Cultivation

*Climate*—*H. brasiliensis* thrives in the tropical belt lying between 15°N and 10°S of the equator, in which the climate is warm, humid and equable and the temperature ranges from 74°F. to 95°F. It requires a well distributed rainfall of 70 to 100 in. per annum; prolonged and heavy rainfall or long intervals of drought are unfavourable; an alternation of moderate showers with frequent intervals of warm bright sunshine is considered to be ideal. The climate in the plantation districts of Malaya and Indonesia approximates more or less to these conditions. In S. India, the plantations are located mostly in areas with a prolonged dry season and severe S.W. monsoon; the temperature ranges from 60°F. to 95°F. and there is a large variation between winter and summer temperatures (Wright, 8; Grist, 77; Troup, III, 850; Yegna Narayan Aiyer, 646).

In its original home, the para rubber tree grows at low elevations, near river banks and creeks along the sea coast which are subject to flooding. Low elevation (up to 800 ft.) valleys, sheltered from strong winds by hills or belts of high forest, offer favourable situations for establishing rubber plantations. In S. India, plantations have been established mainly on the slopes of the western ghats up to an altitude of 1,000 ft., even though a few plantations are situated at higher altitudes; above this altitude, the trees are susceptible to leaf disease, the yields tend to be low and the regeneration of bark is poor (Troup, III, 850; Yegna Narayan Aiyer, 645; Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 1, 3).

*Soil*—*H. brasiliensis* thrives best in deep, well-drained loamy soils. The soils in the rubber plantations of S. India are red lateritic or clayey loams, covered by natural undergrowth or leguminous cover crop and protected from erosion. The soils are generally deep and well drained. They are fairly rich in nitrogen, but poor in mineral constituents (other than iron and alumina). The *p*H tolerance of the plant ranges from 3.8 to 8.0; in alkaline soils, the

*F.R.I., Dehra Dun. Photo: M. V. Laurie*

FIG. 32. HEVEA BRASILIENSIS—PLANTATION

growth is stunted (Yegna Narayan Aiyer, 646; Dijkman, 19).

*Preparation of land*—Rubber is a long duration tree crop which stays on the ground for several years. The economic life of rubber tree is reckoned at 30–35 years. Newly opened jungle is considered to be the most suitable for rubber cultivation. The area to be planted is cleared of the jungle by cutting down the undergrowth and felling the trees. Formerly, the timber and debris were allowed to dry in the open and burnt. Under this system of clearing, the humus in the soil surface was destroyed, nutrient salts of the ash were leached out by rain, and the soil bacteria in the surface layer were destroyed. The present tendency is to give a light burn or no burn at all to the fellings, so as to conserve the humus and prevent, to some extent at least, soil wash and soil erosion. The timber left after the light burn is used for bunds and terraces [Troup, III, 853; Kurien John, *J. sci. industr. Res.*, 1943-44, **2**, 124; *I. & S. Bull.*, 1950, **3**(3), 3; Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 1, 3; Kaimal, *Indian Rubb. Bd Bull.*, 1952, **2**, 6].

TABLE 3—RUBBER HOLDINGS & ESTATES*

(Dec. 1956)

| | No. of units | Area (acres) |
|---|---|---|
| *Holdings* (up to 50 acres) | | |
| up to 5 acres | 30,492 | 56,597 |
| above 5 & up to 10 acres | 2,889 | 20,941 |
| above 10 & up to 50 acres | 1,784 | 36,756 |
| TOTAL | 35,165 | 114,294 |
| *Estates* (above 50 acres) | | |
| up to 100 acres | 204 | 14,308 |
| above 100 & up to 500 acres | 184 | 38,698 |
| above 500 & up to 1,000 acres | 34 | 24,299 |
| above 1,000 & up to 1,500 acres | 17 | 21,085 |
| above 1,500 & up to 2,000 acres | 4 | 6,996 |
| above 2,000 acres | 6 | 14,671 |
| TOTAL | 449 | 120,057 |
| GRAND TOTAL | 35,614 | 234,351 |

* *Rep. Rubb. Bd*, 1956-57, appx III.

TABLE 4—STATE-WISE DISTRIBUTION OF HOLDINGS & ESTATES*

(Dec. 1956)

| | Holdings (up to 50 acres) | | Estates (above 50 acres) | | Total | |
|---|---|---|---|---|---|---|
| | No. of units | Area (acres) | No. of units | Area (acres) | No. of units | Area (acres) |
| Kerala | 35,063 | 112,722 | 410 | 106,902 | 35,473 | 219,624 |
| Madras | 92 | 1,314 | 28 | 9,032 | 120 | 10,346 |
| Mysore | 8 | 199 | 10 | 3,701 | 18 | 3,900 |
| Andamans | .. | .. | 1 | 422 | 1 | 422 |
| Assam | 1 | 50 | .. | .. | 1§ | 50 |
| West Bengal | 1 | 9 | .. | .. | 1§ | 9 |
| TOTAL | 35,165 | 114,294 | 449 | 120,057 | 35,614 | 234,351 |

* *Rep. Rubb. Bd*, 1956-57, appx II. § Not under production though the trees are old.

The cleared area is then 'lined' and marked, and terraces prepared according to the lie of the land. Provision is made for roads and drainage. Planting pits are then dug (size, 2½ ft.×2½ ft.×2½ ft. or 3 ft.×3 ft.×3 ft.) and filled with surface soil and manure. The distance between the pits was formerly 20 ft.×20 ft., i.e., 108 trees per acre. The present system is to plant an initial stand of about 180 trees per acre in the case of bud-grafts or 200 to 300 trees in the case of clonal seedlings. The stand per acre is later reduced to about 150 trees for regular commercial tapping in the seventh or eighth year by selective thinning out of weak, stunted bud-grafts and low-yielding seedling trees respectively. Further thinning is carried out to give a final stand of about 125 trees per acre by the time the trees attain the age of 15 to 20 years. On account of the comparatively poor growth of rubber trees in India, the plantings are closer than in Malaya and Indonesia [Yegna Narayan Aiyer, 646; *I. & S. Bull.*, 1950, **3**(3), 3; Biswas, *Indian J. agric. Sci.*, 1949, **19**, 413; Kurien John, loc. cit.].

A modified practice adopted in rubber plantations is hedge planting, in which the trees are planted in rows, 40–80 ft. apart, with close planting along the hedge. The spaces between the rows are planted with cover plants or catch crops, like coffee, banana and tapioca. Hedge planting is said to possess some advantages as well as certain disadvantages and is still under investigation (Dijkman, 129–34; Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 2, 1949, 15).

In small holdings, para rubber is often grown not as an exclusive crop on virigin soil, but as one among other crops, such as coconut, tapioca and pepper, the area devoted to rubber being sometimes smaller than that of other crops. In such holdings, the amount of attention paid to cultivation and exploitation of

*Rubber Bd. India*

FIG. 33. HEVEA BRASILIENSIS—STRAIGHT LINE PLANTING

rubber trees is determined by the demand and price of rubber (*Rep. Plantation Inquiry Commission, pt III, Rubber*, Govt. India, 1956, 98–101).

*Propagation* – Propagation is done by seeds or vegetatively by buddings or as is more common, by a combination of both. Propagation by seeds was generally adopted prior to 1917. The tree flowers and fruits profusely. The fruits burst open when ripe and the seeds are scattered, sometimes 70–100 ft. away from the tree. The seeds are gathered, and as they lose viability rapidly, are sown fresh or as soon as possible. Under proper storage, the seeds retain viability for about a week to 10 days ; but the viability may be extended to 4 to 6 weeks by packing them in charcoal powder or saw dust with 15–20% moisture in special containers. Seeds collected from seedling trees are sown only to raise stocks for budding. Otherwise, seeds from buddings of selected clones, proved to be potential high yielders are used. In S. India, the seeds are obtainable from July to September (Dijkman, 43 ; Yegna Narayan Aiyer, 645 : Biswas, *Indian J. agric. Sci.*, 1949, **19**, 413).

Seedlings are raised in nurseries or in baskets : they may also be planted directly at stake in the field. Germination takes 1–3 weeks depending upon the freshness of the seed and favourable ecological conditions. With due attention to watering, shading, etc., the seedlings attain a height of 3–4 ft. in 6 months. They are transplanted in the field during the monsoon (Yegna Narayan Aiyer, 645 : Grist, 78 ; Dijkman, 43).

Trees raised from seeds show great variation in latex yield. It has been observed that in a given area of seedling trees, a major part (70–75%) of the total outturn is obtained from 25–30% of trees. In order to exploit fully the high-yielding trees which are fewer in number, vegetative propagation by budding has been recommended. Buds taken from high-yielding trees are grafted on seedlings and the resulting budgrafts (clones) are used for planting.

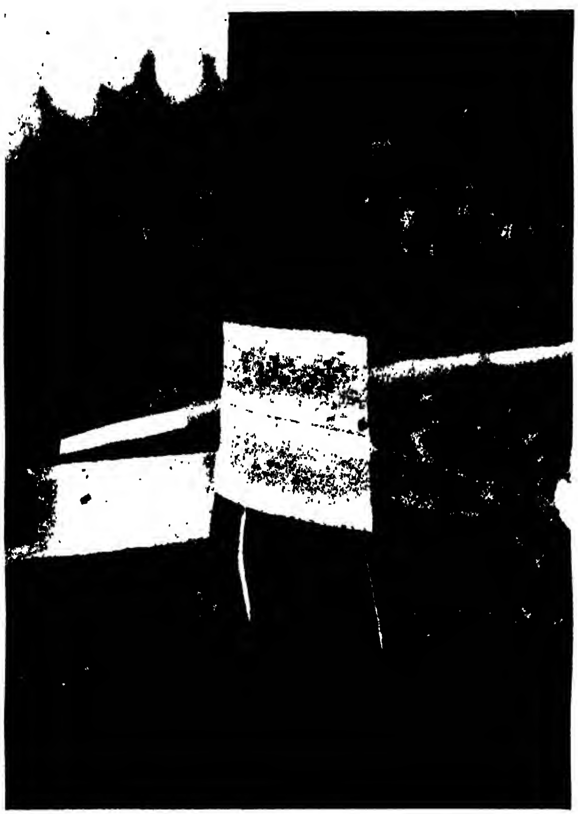
The development of a clone, however, by budgrafting is a laborious process involving observation and study of individual trees over a period of years, and skill and manipulation in grafting. Budgrafting with *Hevea* is not much different from shieldbudding commonly practised with fruit trees. Grafting is usually done in the nursery. Buds from selected trees, preferably from tender branches developed as a result

*Rubber Bd. India*

FIG. 34. HEVEA BRASILIENSIS—SEEDLINGS IN THE NURSERY

of pollarding old branches, are grafted near the base of vigorous seedlings, about one year old (stem diameter, *c.* 1.0 inch). Budwood of different high-yielding clones is also produced in budwood multiplication nurseries. Budded stocks are stumped at 4–6 in. above the bud patch, 1–1½ months after budding, and budded stumps are transplanted in the field 1–2 weeks later when the buds become active. All the shoots which develop from the stock are pruned off. Only the shoot developing from the grafted bud is allowed to grow. Although budding in the nursery is more easy to manipulate, budding in the field is preferred when weather conditions are uncertain (Cherian, *Indian Rubb. Bd, Spec. Leafl.*, No. 3, 1949; Grist, 80; Dijkman, 44–48; Kurien John, loc. cit.).

High-yielding plants may be raised from seeds obtained by artificial or natural crossing between high-yielding clones or by 'selfing' clones grown in large monoclone areas (from buddings of a single good clone) suitably isolated to prevent contamination by foreign pollens. Seeds derived from hand pollination of a clonal tree or trees are termed 'legitimate' seeds, while those obtained from natural pollination where only the mother parent is known are 'illegitimate' clonal seeds. Seedlings raised from clonal seeds, besides possessing the desired characteristics, have the added advantage that in raising them no loss of time is incurred through budding (Cherian, *Plant. Chron.*, 1951, **46**, 550; *Indian Rubb. Bd, Spec. Leafl.*, No. 3, 1949).



*Rubber Bd. India*

FIG. 35. HEVEA BRASILIENSIS—BUD-GRAFTING; BUD PLACED IN POSITION ON THE SEEDLING

*Rubber Bd. India*

FIG. 36. HEVEA BRASILIENSIS—GRAFTED BUD SPROUTING OUT

As a result of studies carried out during the past 3 or 4 decades, particularly in Malaya and Indonesia, budgrafting and propagation by clonal seeds have become established practices in rubber planting. Clones and clonal seeds showing improved yields have been imported into India and tried in various areas. The following are some of the clones tried: *Avros* (*Av.*) from Sumatra; *Bodjong Datar* (*B.D.*), *Tjirandji* (*Tjir.*) and *Djasinga* (*Djs.*) from Java; *Prang Besar* (*P.B.*), *New clones 5 & 6 series, Sabrang, Pilmoor B* (*Pil. B*) and *Glenshiel* (*Gl.*) from Malaya; and *Heneratgoda, Hillcroft* and *Milla-*

*kande* from Ceylon. A few among them have given promising results and are used as planting materials. Recently, new clones, yielding up to 2,400 lb. of dry rubber per acre per annum have been developed in Malaya, Indonesia, Indo-China and Ceylon. A number of proved and promising new clones developed by the Rubber Research Institute of Malaya has been obtained for testing and distribution. The Rubber Research Institute of India has evolved nearly 700 new clones by breeding and selection and they are being tested for distribution [Dijkman, 155 *et seq.*; Cherian, *Indian Rubb. Bd, Spec. Leafl.*, No. 3, 1949; Cherian, *Plant. Chron.*, 1951, **46**, 550; *Indian Rubb. Gr.*, 1954, **3**(4), 14].

Clonal seeds which are comparable with imported ones in performance are being produced in S. Travancore, but the supply is limited. Selfed seeds of clone *Tjir. 1* are available in limited quantity from isolated areas and from monoclone areas in some plantations. Large areas in some plantations are also interplanted with other clones for producing illegitimate clonal seeds. Seeds are collected from selected parts of these areas, where the chances of contamination by foreign pollen are very little. Illegitimate seeds obtained from certain clones, the male parents of which are possibly buddings of other clones, have also given high yielding seed progeny. Considerable areas have been planted with such seedlings. Table 5 gives the characteristics of clones and clonal seeds used as planting materials in India [Cherian, *Indian Rubb. Bd, Spec. Leafl.*, No. 3, 1949; *Plant. Chron.*, 1951, **46**, 550; *Indian Rubb. Bd Bull.*, 1951, **1**, 3, 105; 1952, **2**, 44;

TABLE 5—CLONES & CLONAL SEEDLINGS RECOMMENDED FOR NEW PLANTING AND REPLANTING[1]

| Clones | Country of origin | Remarks |
|---|---|---|
| *Tjir. 1* | Java | Trees generally strong; sensitive to differences in climatic conditions; latex yields decline during hot dry season and increase during wet and cold seasons; recommended for large scale planting |
| *P.B. 86* | Malaya | Prolific seeder; susceptible to *Phytophthora* leaf disease; incidence of *Oidium* leaf disease mild; recommended for large scale planting in S. Travancore |
| *Gl. 1* | Malaya | Maintains high latex yield at 67% intensity tapping system; sensitive to dry conditions; low incidence of *Phytophthora* leaf disease; recommended for large scale planting |
| *Av. 255* | Indonesia | Shy seeder; low incidence of *Phytophthora* leaf disease; recommended for small scale planting |
| *Proefestation (PR.) 107* syn. *L.C.B. 510* | Indonesia | Prolific seeder; recommended for small scale planting |
| *C.H.M. 6* | Not known | Reported to give high yields; bark renewal satisfactory; susceptible to *Phytophthora* leaf disease; recommended for small scale planting |
| *P.B. New Clones 5 & 6 series* | Malaya | Latex yield fairly high; high incidence of brown bast under 100% tapping intensity; recommended for small scale planting |
| *New Chemara (Ch.) Clones* | Malaya | Some clones promising and gave high latex yields in 8-10 years from planting; recommended for small scale planting |
| *B.D. 10* | Java | Shy seeder; low incidence of *Phytophthora* leaf disease; recommended for small scale planting |
| CLONAL SEEDLINGS | | |
| *P.B.I.G. seeds from Plots, C.D. & E.* | Malaya | Latex yield satisfactory; high incidence of brown bast in alternate-day tapping system; recommended for large scale planting |
| *Tjir. 1* | Java | Latex yield satisfactory; selfed and illegitimate seeds available in S. India; recommended for large scale planting |
| *P.B. 'Preliminary Proof' & 'Further Proof' seeds* | | 'Preliminary proof' seeds obtained from artificial crosses between proved parent clones and 'further proof' seeds from a second selection based mainly on yield performance and secondary characters are of superior quality; recommended for small scale planting |
| *Chemara (Ch.) garden 'B' seeds* | Malaya | From *Tjir. 1* and *AV. 157* parent clones; seeds recommended for small scale planting |
| *Chemara (Ch.) garden 'E' seeds* | Malaya | From *BR. 2*, *Tjir. 1*, *Pil. B 84*, *Lunderston N* and *P.B. 86* parent clones; all except *P.B. 86* proved to be good parents; seeds recommended for small scale planting |

[1] Cherian, *Indian Rubb. Bd, Spec. Leafl.*, No. 3, 1949; *Indian Rubb. Bd Bull.*, 1953 54, **3**, 1.

1953–54, **3**, 1 ; *Indian Rubb. Gr.*, 1954, **3**(4), 16 ; *I. & S. Bull.*, 1950, **3**(3), 3].

To encourage the use of improved planting materials, particularly by small holders, the Rubber Board distributes approved clonal seeds and clonal seedling stumps to growers at reduced rates. Seeds are supplied packed with powdered charcoal in gunny bags. Where seedlings are preferred, especially by small holders, the Rubber Board raises seedlings in special nurseries and supplies them. Seedling stumps are generally packed into bundles of 25 or 50, placing layers of leaves between them. In 1955, as many as 32,43,459 seeds, mainly of clone *Tijr. 1*, were distributed among 1,989 holders. Seeds of clones *Tijr. 16*, *Pil. B 84*, *P.B. 5/139*, *P.B. 25*, *P.B. 86* and *B.D. 5*, and mixed seeds from polyclone plantings were also supplied. In the same year, 35,500 clonal seedling stumps and 8,925 budded stumps were distributed. Nearly 24% of the area under rubber cultivation was brought under improved material (Tables 6 & 7) (Cherian, *Indian Rubb. Bd Bull.*, 1951, **1**, 3 ; 1953–54, **3**, 43 ; *Rep. Rubb. Bd*, 1955–56, 46).

*Cultural operations*—These operations are more or less similar to those practised in tea and coffee plantations. In addition to fertilising planting pits and top dressing young plants, proper soil conditions are maintained by cultivating suitable cover crops and adopting soil conservation measures, such as bunding, terracing, silt pitting and drainage (Wlth India, Raw Materials, II, 31, 293 ; Dijkman, 24–27 ; Grist, 82).

Among the factors responsible for the loss of soil fertility in rubber plantations of S. India, mention may be made of heavy rainfall, leading to soil erosion, and high temperature, causing partial soil sterilisation and loss of humus due to oxidation. The loss is particularly severe in young plantations. Cultivation of close-growing cover crops is recommended to check

FIG. 37. HEVEA BRASILIENSIS—PLANTATION OF YOUNG BUDDED TREES

soil erosion and surface run-off. The following legumes are generally used for the purpose: *Pueraria phaseoloides* Benth., *Centrosema pubescens* Benth. and species of *Indigofera, Desmodium, Crotalaria* and *Tephrosia. Albizzia* and *Gliricidia* spp. are used sometimes as shade trees. They provide a green mulch and keep the soil in a state of fine tilth to a depth of several inches [Dijkman, 20–40; Kurien John, *J. sci. industr. Res.*, 1943–44, **2,** 124; Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 1, 3; *I. & S. Bull.*, 1950, **3**(3), 3; Kaimal, *Indian Rubb. Bd Bull.*, 1952, **2,** 6; Yegna Narayan Aiyer, 649; Use of Leguminous Plants, 143; Grist, 81].

Cover crops often tend to retard the development of young rubber plants, while older plants are greatly benefited. Delayed growth in young plantations is, however, compensated by the advantages derived, viz. prevention of soil erosion and enrichment of soil. Among the cover crops tried, *Pueraria phaseoloides* has given good results in S. India. Trials in Malaya and Indonesia have shown that *Centrosema pubescens* is the best for older plantations (Dijkman, 27; Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 1, 3; Kaimal, *Indian Rubb. Bd Bull.*, 1952, **2,** 6).

TABLE 6—ANNUAL PLANTINGS WITH DIFFERENT PLANTING MATERIALS* (1938-1956)
(area in acres)

| | Ordinary seedlings | Clonal seedlings | Budgrafts | Total |
|---|---|---|---|---|
| Planted earlier than 1938 | 95,832 | 338 | 7,566 | 1,03,736 |
| 1938 | 541 | 15 | 1,276 | 1,832 |
| 1939 | 1,255 | 527 | 2,322 | 4,104 |
| 1940 | 1,775 | 517 | 1,862 | 4,154 |
| 1941 | 776 | 87 | 1,315 | 2,178 |
| 1942 | 3,049 | 576 | 2,385 | 6,010 |
| 1943 | 10,150 | 1,630 | 2,768 | 14,548 |
| 1944 | 8,591 | 1,345 | 1,500 | 11,436 |
| 1945 | 7,690 | 2,599 | 725 | 11,014 |
| 1946 | 4,469 | 718 | 585 | 5,772 |
| 1947 | 5,099 | 494 | 899 | 6,492 |
| 1948 | 3,790 | 206 | 526 | 4,522 |
| 1949 | 2,173 | 246 | 308 | 2,727 |
| 1950 | 1,958 | 436 | 265 | 2,659 |
| 1951 | 616 | 514 | 612 | 1,742 |
| 1952 | 1,334 | 643 | 702 | 2,679 |
| 1953 | 1,934 | 397 | 929 | 4,260 |
| 1954 | 5,792 | 3,019 | 1,323 | 10,134 |
| 1955 | 12,264 | 5,020 | 1,099 | 18,383 |
| 1956 | 8,279 | 6,020 | 1,670 | 15,969 |
| TOTAL PLANTED AREA | 1,77,367 | 26,347 | 30,637 | 2,34,351 |

* *Rep. Rubb. Bd*, 1956-57, appx I.

TABLE 7—ACREAGE UNDER DIFFERENT PLANTING MATERIALS IN ESTATES AND SMALL HOLDINGS* (DEC. 1956)

| | Estates | Small holdings | Total | % of total acreage |
|---|---|---|---|---|
| Ordinary seedlings | 81,184 | 96,183 | 1,77,367 | 76 |
| Clonal seedlings | 13,219 | 13,128 | 26,347 | 11 |
| Budgrafts | 25,653 | 4,984 | 30,637 | 13 |

* *Rubb. Bd Bull.*, 1956-57, **4** (4), 80.

The need for manuring was not felt at the early stages of the plantation industry in India, as the trees were raised on rich virgin soils. But when cultivated lands came to be used for planting, as in many of the small holdings in Kerala, manuring became necessary. Nitrogenous fertilizers, particularly sulphate of ammonia, was found not only to help growth, but also to counteract and alleviate the ill effects of *Oidium* leaf disease. Applications of complete fertilizers, including potash and phosphate, however, gave better results, particularly in areas which have been under rubber for 20–30 years and where replanting with high-yielding trees is contemplated. Manuring is beneficial to growth, bark renewal and latex yield during early stages. Its effects on latex yield from older trees, however, are not immediate: it brings about a gradual improvement in the condition of the trees and serves as a restorative to foliage deterioration, bark renewal and consequent yield increase. Manurial experiments conducted so far have shown, that a mature stand of 150 trees removes from the soil approximately 5,500 lb. of nitrogen, 8,250 lb. phosphoric acid and 6,650 lb. potash. In order to replenish in part at least, the nutrients thus lost, it is necessary to adopt a regular manuring schedule. Schedules suitable for Indian conditions, not only for mature trees under tapping, but also for young rubber trees in pre-tapping stage and for seedlings in the nurseries have been drawn up (Table 8). The application of these mixtures is made in one or more doses. In case where magnesium deficiency is indicated by yellowing of the leaves between the veins, addition of magnesium sulphate at the rate of 10 lb. for every 100 lb. of mixture is advised [Haines &

TABLE 8—COMPOSITION OF FERTILIZER MIXTURES*

(per cent by weight)

| | A | B | C |
|---|---|---|---|
| Ammonium sulphate | 40 | 37 | 35 |
| Raw bonemeal (3% N & 22% $P_2O_5$) | .. | 10 | 15 |
| Rock phosphate (35% $P_2O_5$) | 28 | 28 | 20 |
| Superphosphate (16% $P_2O_5$) | 15 | .. | .. |
| Pot. chloride (60% $K_2O$) | 17 | 20 | 20 |
| Groundnut meal | .. | 5 | 10 |
| Percentage of N, $P_2O_5$ & $K_2O$ respectively in mixtures | 8-12-10 | 8-12-12 | 8-10-12 |

* Nair, *Rubb. Bd Bull.*, 1957, **4** (2 & 3), 7. A—For nursery. B—For young rubber. C—For trees in tapping.

Guest, *Emp. J. exp. Agric.*, 1936, **4**, 300; Lock, 116; *Indian Rubb. Bd Bull.*, 1953–54, **3**, 46; Nair, *Rubb. Bd Bull.*, 1957, **4**(2 & 3), 7].

*Diseases*—As many as 95 species of fungi have been recorded on rubber trees in Malaya, but most of them are harmless. In India, rubber trees are relatively free from root diseases, but the incidence of leaf diseases is rather severe.

Some of the serious diseases of rubber are caused by *Phytophthora* spp. *P. palmivora* Butler (syn. *P. meadii* McRae) is common in India and causes fruit rot, leaf fall and black thread. Fruit rot and abnormal (secondary) leaf fall are inter-related and their outbreak is attributed to the extreme monsoon climate prevailing in Indian plantations. The fruits are first affected; the affected fruits begin to show dull, ashy grey portions on the surface; drops of latex appear, and the surface finally becomes dark and sodden. Decayed fruits remain hanging on the tree for a considerable time and then fall off. With the onset of S.W. monsoon, infected trees begin to shed leaves, the leaf fall being most noticeable in July-August. The leaf stalk is discoloured and blackish brown for the greater part of its length; it may also remain green. Discoloured stalks often bear small drops of latex (MacRae, *Plant. Chron.*, 1916, **11**, 459; McRae & Sundararaman, ibid., 1915, **10**, 452; Petch, 100–105).

Spraying with Bordeaux mixture before the onset of monsoon has been recommended as an effective control measure. Dusting with 6% Cuprosana is reported to give satisfactory results. Development of resistant varieties provides the most effective solution. A high correlation exists between the rate of fruit setting and incidence of the disease, and high-yielding clones which do not bear fruits are resistant. Clones *B.D. 10* and *AV. 255*, which are shy seeders, are resistant to fruit rot. *Gl. 1* is also fairly resistant (Petch, 107–11; Kaimal, *Indian Rubb. Bd Bull.*, 1953–54, **3**, 37; Venkataramani, ibid., 1953–54, **3**, 94; *Plant. Chron.*, 1954, **49**, 513).

Black thread (black stripe, blackline canker, bark rot, decay of renewing bark, cambium rot and stripe canker) is another *Phytophthora* disease, which manifests itself as a series of narrow, vertical, black lines parallel to one another, just above the tapping cut. The lines broaden out laterally and coalesce to form a continuous wound parallel to the tapping cut. Sometimes the lines extend into the wood. Wet weather favours the onset of disease. Painting of tapping cuts, after each tapping, with a 5% solution of Brunolinum, Brunolinum Plantarium, Carboli-

*Rubber Bd. India*

FIG. 38. HEVEA BRASILIENSIS—TREES RENDERED LEAFLESS BY P. PALMIVORA INFECTION

neum Plantarium, Agrisol, Solignum or Jodelite, prevents the incidence of black thread (Petch, 119–25, 133; Dijkman, 148).

Die-back due to *Phytophthora* sp. follows abnormal leaf fall. A common die-back disease on seedlings and budded rubber saplings (2–3 years old) is caused by species of *Gloeosporium* and *Phyllosticta*. *Botryodiplodia elastica* Petch and *B. theobromae* Pat. also cause a die-back which manifests first at the top and progresses rapidly down the main stem killing off the branches in succession. The infection enters the stem through shoots killed by *Gloeosporium* and *Phyllosticta* spp. Water-logged conditions, presence of hard rocks at the soil surface and nutrient deficiency also cause die-back. The disease is controlled by cutting off the affected parts, about a foot below the dead part, and burning them (McRae, *Plant. Chron.*, 1916, **11**, 459; Petch, 106, 145–51; Kaimal, *Indian Rubb. Bd Bull.*, 1953–54, **3**, 37).

Powdery or leaf mildew is caused by *Oidium heveae* Steinmann. The fungus attacks young leaves refoliating after annual wintering, particularly late wintering trees. Young, tender, brown leaves just unfolding are usually attacked on the underside of the midrib. They shrivel from the point of infection to the tip, turn purplish and then black, curl up and fall off. Light showers followed by cool and cloudy weather during refoliation favour the outbreak of disease. The disease occurs in a virulent form in hilly areas at altitudes of 1,000 ft. and above, particularly in S. Travancore where the climate is drier and the rainfall much less than in central or north Travancore. It usually assumes a severe phase in February. Spraying with Bordeaux mixture and dusting with sulphur powder are recommended as control measures (Petch, 91–93, 98; Mitra & Mehta, *Indian J. agric. Sci.*, 1938, **8**, 185; *Indian Rubb. Bd Bull.*, 1953–54, **3**, 57; Dijkman, 150; *Adv. Circ. Rubb. Res. Inst., Ceylon*, No. 43, 1954).

Pink disease caused by *Pellicularia salmonicolor* (Berk. & Br.) Dastur (syn. *Corticium salmonicolor* Berk. & Br.) manifests itself as a pink encrustation on the bark. It originates at the forking of branches or in areas where several branches arise from a single main stem. The pink patch gradually extends and covers the circumference and the bases of adjacent branches up to several feet. The bark in the centre of the patch dies out but that towards the margin may still be alive. The dead bark cracks and splits away from the wood and the fungus penetrates into the wood beneath. The disease is checked in the early stages of attack by spraying with Bordeaux mixture or painting with Fylomac 90. Cutting of affected parts followed by application of coal tar to the wound is recommended in the case of mature trees. Painting with Carbolineum mixture or asphalt-kerosene mixture is also recommended (Petch, 134–42; *Indian Rubb. Bd Bull.*, 1951, **1**, 97; Dijkman, 150).

Mouldy rot is a disease of the tapping panel caused by *Ceratostomella fimbricata* (E. & H.) Jac. (*Sphaeronema fimbricatum*). The fungus infects exposed soft tissues of freshly tapped bark under damp conditions. The disease manifests as small discoloured patches, darker than the normal tapped cortex, which subsequently spread and coalesce to form an irregular band of dead tissue, parallel to and about an inch above the tapping cut. The affected bark rots within 3–4 weeks, forming large open wounds and exposing diseased and discoloured wood. If tapping is continued, the disease follows the tapping cut down the stem. The dead tissue scales off on drying and islands of callus are formed beneath. S.W. monsoon favours the outbreak of the disease. Infected trees should be rested for at least a month; painting with 'Burma paste' or weak Izal preparations and disinfection of collecting cups and tapping knives are recommended (Petch, 153–54; Dijkman, 149; Kaimal, *Indian Rubb. Bd Bull.*, 1953–54, **3**, 37; Yegna Narayan Aiyer, 657).

Brown bast is a physiological disease which causes drying up of a part or whole of the tapping cut, with consequent cessation of latex flow. The disease is caused by over-tapping. Affected tissue becomes discoloured and cankerous wood growth, which may destroy the tapping panel, may develop. Less intensive tapping and resting of trees are effective against brown bast incidence (Petch, 169–80; Kaimal, *Indian Rubb. Bd Bull.*, 1953–54, **3**, 37; Dijkman, 151).

Other diseases of rubber recorded in India, but not considered serious, are: brown root rot [*Fomes lamaoensis* (Murr.) Sacc. & Trott.], red rot (*Sphaerostilbe repens* Berk. & Br.), charcoal rot [*Ustulina maxima* (Web) von Wettstein syn. *U. zonata* (Lev.) Sacc.], leaf spot (*Colletotrichum heveae* Petch), bird's eye spot (*Helminthosporium heveae* Petch), white spongy rot (*Polystictus personii* Fr.) and rim blight (*Sphaerella heveae* Petch) (*Indian J. agric. Sci.*, 1950, **20**, 107, Kaimal, *Indian Rubb. Bd Bull.*, 1953–54, **3**, 37; Dijkman, 144–147).

Species of *Loranthus* are frequently found growing

parasitically on the branches of rubber trees. They should be removed by cutting and affected branches pruned. Spraying with 2% 2,4,5-T in diesel oil is reported to have given promising results (*Rep. Rubb. Bd*, 1955–56, 38).

*Pests*—Rubber trees are not subject to any serious pests. The mango stem borer beetle (*Batocera rubus* L.), bark beetle (*Xyleborus biporus* S.) and scale insects (*Aspidiotus cyanophylli* S. and *Saissetia nigra* N.) sometimes cause damage. Horses, cattle, goats, monkeys, wild pigs, deer, porcupines, antelopes, rats, squirrels and rodents cause damage to the trunk, branches and bark of rubber trees. Wild elephants are a menace in interior planting districts. White ants cause serious damage to trees at all stages. In Indonesia, a giant snail is reported to be a serious pest to young rubber plantings [Ramakrishna Ayyar, 365; Petch, 223–24; Grist, 89; *I. & S. Bull.*, 1950, 3(3), 3; Dijkman, 153].

### Tapping

*H. brasiliensis* is valued for the latex obtained by tapping, i.e. opening up the latex vessels situated in the bark with a sharp incision on the main trunk. The latex vessels are arranged in concentric cylinders and run in counter-clockwise spirals up the trunk. When the vessels are cut, the latex flows out, quickly at first, then slowly, and finally coagulating on the cut surface. The tree is rested after each cut for varying periods according to age, climate and condition of the tree. When the tree is tapped again, the coagulated latex or 'plug' from the old cut surface is removed and a thin strip of bark of approximately the same width as that of the plug is cut off. During the first tapping, only a small amount of viscous latex exudes. The flow increases with each successive tapping and the viscosity decreases till an equilibrium between the amount of latex and its rubber content is reached

FIG. 39. HEVEA BRASILIENSIS—TAPPING TREES IN AN ESTATE

(Kaimal, *Indian Rubb. Bd Bull.*, 1951, **1**, 25; Grist, 84; Dijkman, 70).

Tapping consists in the removal, by excision, of a thin paring of bark, 1/30–1/20 in. thick, at regular intervals, the cuts being opened always at an angle to the horizontal. Usually, the cut extends half way around the trunk, but quite often, it may completely encircle it. Based on the type and extent of cut made, tapping systems are termed Half Spiral system, Full Spiral system, V-cut system and Herring Bone system. In the single half-spiral system, which is more commonly employed in the plantations of South-east Asia, the cut is made at 30–35° to the horizontal, from the upper left to the lower right, half way around the tree; at the lower end of the cut, a vertical cut is made to conduct the latex to a cup placed below. In the V-cut system, two slanting incisions are made and at the base of their junction below, a cup is fitted to receive the latex. The herring bone system was much in vogue in the earlier years of the plantation industry; a vertical cut was made in the bark with 4–6 diagonal cuts draining into the vertical cut from either side and extending from one-fourth to one-half the circumference of the tree. Wild rubber is tapped in Brazil by making vertical incisions in the bark with an iron axe and the latex is collected in tin cups (Grist, 85; Yegna Narayan Aiyer, 651).

Uniform methods of measuring and naming the systems in terms of type, number and length of cuts per tree, and period and cycle of tapping have been evolved in plantations. The amount of tapping is expressed as a fraction of the circumference. For estimating the relative intensity, a quarter cut tapped daily is taken as the standard (100%). In S. India, the half spiral, alternate day tapping (S/2, d/2, 100%) is usually employed. Young gardens are not subjected to 100% relative tapping intensity. In Malaya and Indonesia, systems, such as one third spiral, alternate day tapping (S/3, d/2, 67%) and half spiral, every third day tapping (S/2, d/3, 67%) are employed (Dijkman, 74; Fuller, *Econ. Bot.*, 1951, **5**, 311).

Only the basal portion of the trunk, up to 4 ft. from the ground, is usually tapped, although the initial height for opening the cut on young trees varies with seedlings and buddings. In clonal seedlings, the number of latex vessels and the bark thickness increase towards the base; the tapping cut is, therefore, made at a lower height than in buddings; in buddings the position of the tapping cut causes little difference in latex yield.

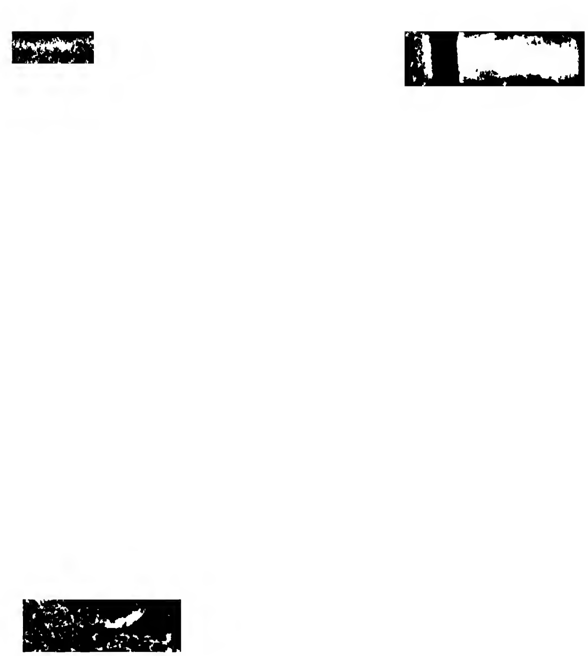


FIG. 40. HEVEA BRASILIENSIS—BASAL PORTION OF TREE WITH TAPPING PANEL AND LATEX CUP

Cuts are made by special tapping knives, which can be adjusted to cut to the proper depth and angle. The knife commonly used in India is the *Michie Golledge* designed to remove a thin shaving of bark, leaving a surface sloping slightly inwards to prevent the latex from overflowing down the bark. The diagonal left-to-right cut intercepts the maximum number of latex vessels. The latex is collected through a small spout (fixed into the bark) in a cup made of tinplate, aluminium or enamelled iron; coconut shells may also be used. The cup is of sufficient size to hold a day's flow. Tapping is invariably done early in the morning when the flow of latex is vigorous. The flow diminishes with rise in temperature and ceases in about 3 hours. Depending upon the distance of planting and lie of the land, an average tapper taps 200–300 trees, in three hours. After the last groove has been cut, the tapper goes

back to empty the cups. A few drops of dilute ammonia solution are sometimes added to the latex to prevent coagulation. The latex is transferred into large pails or buckets, thence to tanks and transported to coagulating sheds or estate factories (Kaimal, *Indian Rubb. Bd Bull.*, 1951, **1**, 25; Grist, 86; Dijkman, 70; *Indian Rubb. Bd, Serial Pamphl.*, No. 3, 1949, 15; Yegna Narayan Aiyer, 652; Kurien John, *J. sci. industr. Res.*, 1943–44, **2**, 124).

The depth of tapping and the rate of bark consumption (rate at which bark is shaved) exert considerable influence on latex production. The yield increases with increase in the depth of scraping due to the opening up of more latex vessels. Injury to cambial tissues, which regenerate the cut bark and maintain productivity by forming new latex vessels, must be avoided. In S. India, a safe margin of 2–2½ mm. of bark above the cambial zone is left untapped, as against 1–1½ mm. allowed in Malaya and Indonesia. The higher margin allowed in India is due to the comparatively poor rate of bark renewal. Further, bark about 1/30 in. thick is removed per tapping day in India, compared to 1/20 inch in Malaya and Indonesia, the corresponding monthly bark consumption being ½ in. and ¾ in. Starting with an initial height of about 40 in. from the ground, it takes nearly 60–80 months before the bark from one half of the tree trunk is removed down to the ground level. When this panel is completed a fresh panel on the opposite side of the tree is taken up and tapping is continued for 5–6 years, during which time the first half has regenerated new bark and becomes ready for tapping. The tapping of alternate panels at intervals of 5–6 years is continued till the tree comes to the end of its tapping life.

Tapping commences when the tree is 7–8 years old. In Malaya and Indonesia, tapping commences

FIG. 41. HEVEA BRASILIENSIS—TAPPERS TAKING LATEX TO THE FACTORY

when the trees are 5–6 years old. The yield of latex increases every year and reaches the maximum when the tree is about 20 years old. Under proper management, the yield may be sustained for 40–50 years or even more (Dijkman, 70; Grist, 84; Fuller, loc. cit.; Kaimal, *Indian Rubb. Bd Bull.*, 1951, **1**, 25).

During World War II, efforts were made to augment rubber production in India by adopting a system of intensive tapping. Two parallel cuts, *c.* 15 in. apart, were made half way around the tree and a cycle of three days was adopted. This method gives higher latex yields than the half spiral, alternate day system (Kurien John, *J. sci. industr. Res.*, 1943–44, **2**, 124).

While tapping schedules in large estates are based on a study of bark consumption and regeneration, many small holdings follow a system of daily tapping without attention to bark regeneration. This practice affects the health and longevity of trees (Kaimal, *Indian Rubb. Bd Bull.*, 1951, **1**, 25).

The yield of rubber can be increased by treating the bark, below the tapping cut, with yield-stimulating mixtures, containing plant hormones and selective weed-killers with hormone properties. Proprietary mixtures, e.g. Stimulex and Eureka, and the sodium salt of *n*-butyl ester of 2, 4-dichlorophenoxy acetic acid (2, 4-D), at concentrations of 1–2% in palm oil, are effective in increasing latex yield. It has been found that the response to stimulants is better in poor to average yielding trees than in high-yielding ones, and in seedling trees than in budgrafts. Indole-3-acetic acid, indole-butyric acid and lanolin may be employed for stimulating bark renewal. Indole-3-acetic acid is effective in high concentrations, at least in the early stages, while indole-butyric acid is most effective at low concentrations; lanolin increases bark renewal by 17% in the first month of application. Injection of copper sulphate in holes bored into the trees at the level of the cut also increases latex yield; but the treatment is not recommended as it has undesirable side effects. Many rubber estates in India employ 2,4,5-T in palm oil to stimulate latex yield from low-yielding trees. Attempts are being made to replace palm oil by locally available oils (Chapman, *Indian Rubb. Bd Bull.*, 1952, **2**, 16; 1953-54, **3**, 8, 62; Tixier, ibid., 1952, **2**, 22; Muzik, *Pap. Mich. Acad. Sci.*, 1949, **35**, 33; *Rep. Rubb. Bd*, 1955–56, 28).

*Yield*—The average yield of latex per acre in India (Table 9) from unselected ordinary seedling trees (which account for 80% of the rubber) is 300 lb., as compared to 450 lb. for similar trees in Malaya. For improving the yield, it is essential that new plantings or replantings should be done solely with improved planting materials. The yield from bud-grafted trees of approved clones and from clonal seedlings of approved parentage is twice, sometimes more, than that obtained from unselected seedlings. An average yield of 700–800 lb. per acre has been obtained with improved planting materials in India, although yields as high as 1,500–2,000 lb. per acre have been reported from Malaya, Java, Sumatra and Ceylon. The low yields in India are attributed to climatic and soil conditions, seasonal fluctuations and the comparatively small number of mature bud-grafted and clonal seedlings under tapping. The yields also show great fluctuations from month to

TABLE 9—AVERAGE YIELD OF RUBBER*

(lb. per acre of tapped area)

| | 1950 | 1951 | 1952 | 1953 | 1954 |
|---|---|---|---|---|---|
| Travancore-Cochin | 310 | 313 | 336 | 303 | 278 |
| Madras | 287 | 281 | 273 | 242 | 253 |
| Coorg | 256 | 270 | 265 | 265 | 258 |
| Mysore | 158 | 158 | 145 | 139 | 208 |
| All-India | 305 | 307 | 323 | 294 | 274 |

* *Rubber in India*, 1954, Table 3.

TABLE 10—MONTHLY PRODUCTION OF RUBBER IN INDIA*

(qty in tons)

| | 1950-54 (av.) | 1955 | 1956 | 1957 |
|---|---|---|---|---|
| January | 1,628 | 1,700 | 2,083 | 2,190 |
| February | 318 | 434 | 976 | 1,165 |
| March | 1,054 | 1,329 | 1,279 | 1,220 |
| April | 1,858 | 2,277 | 1,826 | 2,072 |
| May | 1,751 | 2,085 | 1,983 | 1,645 |
| June | 1,019 | 1,037 | 1,484 | 750 |
| July | 1,177 | 1,636 | 1,730 | 1,499 |
| August | 1,466 | 1,756 | 1,750 | 2,341 |
| September | 2,106 | 2,310 | 2,293 | 2,712 |
| October | 2,036 | 2,450 | 2,326 | 2,768 |
| November | 2,319 | 2,680 | 2,800 | 2,855 |
| December | 2,317 | 2,787 | 2,914 | 2,550 |
| TOTAL | 19,049 | 22,481 | 23,444 | 23,767 |

* *Rubb. Bd Bull.*, 1956 57, **4** (4), 85.

month (Table 10). The average number of tappings per year ranges from 120 to 140 in India as against 160 in Malaya, where the rains are more evenly distributed throughout the year and the monsoon does not seriously interfere with tapping operations [Fuller, loc. cit.; Kaimal, *Rubb. India, Spec. Conf. Number*, 1954, **6**, 27; *Indian Rubb. Bull.*, No. 75, 1955, 9; Yegna Narayan Aiyer, 654; *I. & S. Bull.*, 1950, **3**(3), 3].

### Latex

*Physical properties*—Fresh latex is usually milky white in colour; it may be grey, yellow or slightly pink, depending upon the season and local conditions. The latex drawn from a tree which has been rested for some time is yellow; the colour changes to milky white after the tapping is continued for a few days. Fresh latex has the following physical characteristics: sp. gr., 0.970–0.980; viscosity at 28° (Garter's pipette viscometer), 8.0; and surface tension at 30°, 40.5 dynes/cm. The viscosity of latex varies with the concentration of rubber, size of rubber particles, duration of tapping, age of the tree, and other factors. Ammoniated latex has a much lower viscosity (4–5.5) than raw latex. The surface tension decreases when latex is stored for some months.

Latex as it flows from the tree is almost neutral in reaction (*p*H, *c.* 7); it turns acid readily owing to enzymic and bacterial action and the latex coagulates when left standing for some time. The particles in the fresh latex carry a negative charge with a contact potential of $-0.035$ volts; they become positively charged when sufficient acid is added to bring down the *p*H to 3.5.

Coagulation of latex is brought about by the addition of acids, neutral salts and water-miscible organic solvents, such as alcohol and acetone. Acids depress the ionization of the interfacial film and so reduce the particle charge; salts (particularly di- and trivalent cations) increase the concentration of positive ions in the ionic atmosphere, and solvents reduce the hydration of particles. Coagulation is also brought about by excessive friction, addition of protein precipitants and evaporation (Flint, 51–70; Kirk & Othmer, XI, 820; Thorpe, X, 554).

*Chemical properties*—The latex obtained by tapping *H. brasiliensis* is essentially a colloidal suspension of rubber particles in an aqueous serum. The particles range in size from 0.03$\mu$ to 3.0$\mu$ (av. 0.5$\mu$) in diameter and are spherical to pear-shaped in form. Small spherical particles are characteristic of latex from young trees, while large pear-shaped ones, formed by the coalescing of smaller spherical particles are typical of latex from mature trees. The individual particles consist of three parts: an interior semi-fluid material of pure rubber hydrocarbon soluble in benzene, a viscous rubber skin permeable to benzene (but only slightly soluble in benzene), and an external protective layer, probably proteinous in nature, which is lyophilic (Flint, 71–81; Bonner & Galston, *Bot. Rev.*, 1947, **13**, 543).

Besides rubber particles, fresh undiluted latex contains yellowish particles, termed lutoids, in colloidal dispersion. The lutoid particles are composed of a viscous protein phase with high magnesium content (Kirk & Othmer, XI, 820; Stevens, 19).

The latex contains 25–40% (av. 30%) rubber hydrocarbon. Analyses of latex from 4-year old and 10-year old trees gave the following values respectively: water 70.00, 60.00; rubber hydrocarbon, 27.07, 35.62; acetone-sol. matter, 1.22, 1.65; protein, 1.47, 2.03; and ash, 0.24, 0.70%. The rubber and non-rubber contents increase as the age of the tree advances from 4 to 10 years, after which the increase is not perceptible. The composition of latex from tender twigs and leaves differs from that of latex tapped from the trunk. Analysis of latex from the leaf petioles gave (dry matter): rubber, 78.7; ash, 1.2; proteins, 13.0; and acetone-sol. matter, 7.1%. The latex from the hard bark is richer in rubber, and correspondingly poorer in nitrogenous compounds, acetone-soluble matter and ash than the latex from the soft bark; the *p*H is higher (Thorpe, X, 554; Flint, 62–64; Stevens & Stevens, 23; Dijkman, 91).

Non-rubber constituents present in the latex include proteins, resins, sugars and glycosides, tannins, alkaloids and mineral salts; some of them are adsorbed on the surface of the rubber particles, while others are present in the serum. The following constituents have been reported in fresh latex (moisture, 69.78; rubber hydrocarbon, 27.17%): a complex containing protein, phosphate, sugars, quebrachitol and inorganic compounds, 1.45; ether soluble plastic material containing sulphur, 0.94; a complex of saturated and unsaturated fatty acids with terpenic material, 0.33; high aliphatic alcohol ester of a water-soluble aldehydic or ketonic acid, 0.06; and ammonium salt of a water-soluble aldehydic or ketonic acid, 0.03%. Some of the non-rubber constituents help stabilisation of the latex, some affect the color, and others influence the physical characteristics of rubber (Kirk & Othmer, XI, 818, 820).

The nitrogenous compounds of latex include at least three types of proteins, viz. glutelin, globulin and albumin; glycine and other monoamino and diamino acids and amides are also present. The proteins occur as an adsorbed layer on the surface of rubber particles and are responsible for their lyophilic character; the rubber hydrocarbon itself is lyophobic. The proteins present in the serum (0.3–0.5%) are similar to those present in the adsorbed form (Davis & Blake, 600; Kirk & Othmer, XI, 819; Bonner & Galston, loc. cit.).

The acetone-soluble matter (latex resins) is a complex mixture of fatty acids, fats and phytosterols. The resins are believed to occur in fresh latex as dispersed particles comparable in size and shape to rubber globules. Some of them are retained in prepared rubber and help to protect the hydrocarbon against atmospheric oxidation. Two sterols ($C_{27}H_{42}O_3$ and $C_{20}H_{30}O$) possessing protective properties have been isolated from the unsaponifiable fraction of the acetone extract. Phosphatides (0.1–0.2%) present in the latex consist of equal proportions of lecithin and of calcium and potassium salts of phosphatide acids. The phosphatide fatty acids (iod. val., 90–112) contain: 21–26% saturated acids (palmitic, stearic and arachidic) and 79–74% unsaturated acids (oleic and linoleic) (Stevens & Stevens, 22; Hilditch, 1947, 207; Flint, 90; Davis & Blake, 601).

Sugars and glycosides act as intermediates in the biosynthesis of rubber from cellulose and starch. Dambonitol, bornesitol, matezitol, dambose and quebrachitol (0.5–2.0%) have been identified. The last named compound may be extracted from the serum after the coagulation of rubber and used in the preparation of lacquers (Flint, 99; Alphen, *Industr. Engng Chem.*, 1951, **43**, 141).

Fresh latex contains oxidase, peroxidase, catalase, tyrosinase and esterase. The esterase hydrolyses simple esters readily (Wehmer, II, 679; Haan-Homans, *Industr. Engng Chem.*, 1951, **43**, 403).

The ash constituents present in fresh latex (ash content, 0.3–0.7%) are: $P_2O_5$, 36.1–37.3; $K_2O$, 35.6–40.7; MgO, 4.4–5.1; CaO, 4.9–5.0; $Na_2O$, 4.4–6.2; $Fe_2O_3$, 1.5–1.7; $Al_2O_3$, 0.5–0.6; $SiO_2$, 2.1–2.5; Cl, 1.5–2.8; and $SO_3$, 1.6–1.9%; rubidium, copper and manganese are present. The presence of inorganic salts renders latex films water-absorbent (Bonner & Galston, loc. cit.; Kirk & Othmer, XI, 819; Davis & Blake, 601).

*Preservation & concentration*—Fresh latex is readily susceptible to enzymic and bacterial action leading to acid formation, and preservatives and bactericides are usually added to latex at the time of collection to inhibit acid development and consequent coagulation. Ammonia, formaldehyde, sodium hydroxide, soap, and bactericides, such as pentachlorphenol, are used as preservatives. In plantation practice, a small quantity of ammoniated water is placed in the collection cup; the latex, after pooling, is treated with ammonia (gas) to raise the concentration to 0.1–1.0%. The addition of 3 parts of 25% ammonia solution to 100 parts of latex ensures the stabilisation of the latter for 6 months.

'Normal latex' is the term applied to stabilised fresh latex free from sludge. It contains 30–40% solids; it is usual in commercial practice to concentrate the latex by evaporation, creaming or centrifugation to give a product with a higher solid content. Concentration helps saving on freightage: further, concentrated latex offers certain advantages in the manufacture of rubber articles.

In the evaporation method, stabilised latex is heated in a water-jacketed, horizontal rotating cylinder with air circulation or in a vacuum evaporator. The viscous product [dry rubber content (D.R.C.), 68%; non-rubber constituents, 7%] is marketed under the trade name Revertex.

Concentration by creaming is effected by the addition of 'creaming' agents, e.g., alginates, to accelerate the phase separation of rubber particles. Among other creaming agents in use, mention may be made of gelatin, hemicelluloses, pectins and gums; tamarind seed powder has been tried in India. Ammoniated latex is mixed with a creaming agent (up to 0.5%), stirred and allowed to stand for several days when it separates into two layers: the lower serum layer is drawn off and the treatment repeated until the desired concentration (usually 60% D.R.C.) of rubber is reached in the top layer. The product shows an 'after creaming' tendency, which is considered a disadvantage.

Centrifugation is essentially an accelerated creaming process. When the latex is passed through a centrifuge, a rubber concentrate floats to the top: at the same time, adventitious foreign matter separates out and a 'refined' concentrate is obtained (D.R.C., 60–62%; non-rubber constituents, 2%).

A recent development in latex concentration is electrodecantation. The latex is placed between two electrodes with intervening semi-permeable membranes. When a direct current is passed, the negatively charged rubber particles migrate towards the

anode: the membranes intercept their passage and cause accumulation. On reversing the current, the particles are driven back from the membranes and rise to the surface. Concentrated latex so prepared possesses high mechanical and chemical stability (Flint, 156–225; Kirk & Othmer, IX, 818–23; Thorpe, X, 553, 562; Stevens, 17, 32–42; Grist, 94; Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 2, 1949, 6).

### Raw Rubber

*Manufacture of raw rubber*. Rubber of commerce is obtained from *Hevea* latex by coagulation, rolling and drying. Two forms of raw rubber (First Grade Latex Rubber) are known in trade, namely, Smoked Sheet Rubber and Crepe Rubber. The bulk of plantation rubber in South-east Asia is converted into smoked sheet rubber. This is done in well equipped factories situated near the plantations or in sheds attached to small holdings. The latex as received is diluted with water to c. 15% D.R.C., strained through a sieve (60–100 mesh) to remove gross impurities and

FIG. 42. HEVEA BRASILIENSIS—STRAINING THE LATEX

acetic or formic acid is added to coagulate the rubber. About 2 lb. of acetic acid or 1 lb. of formic acid are added to coagulate 400 lb. of rubber latex. The acidified latex is poured into aluminium pans or tanks fitted with vertical separation plates and allowed to stand overnight. Pans are used in small estates and holdings, and tanks in large estates. The rubber coagulates between the separating plates and floats on the surface as a soft, white, spongy slab. When the slabs become firm, the plates are removed, and the slabs lifted out and washed in water.

Washed slabs are rolled between smooth rollers to squeeze out the water and flatten them to a thickness of about 1/8 in. Hand rollers are generally employed for this purpose in the smaller estates and holdings; power-operated rollers are used in estate factories. The sheets are passed through marking rolls to impart a ribbed pattern. The increased surface produced by ribbing helps to accelerate drying; also, the ribs prevent the sheets from adhering to one another when piled. Ribbed sheets (moisture content, 20%) are partially dried on racks or poles in shade for a few hours and then transferred to smoke houses (temp., 40–50°) where they are exposed to smoke from burning firewood. Smoking hastens drying and prevents mould growth. The smoking period varies from 7–9 days in old fashioned smoking sheds to 4 days in well designed modern smoke houses. The dried product is collected and packed for the market. Smoked sheets are translucent, amber-coloured, elastic and durable [Fuller, loc. cit.; Grist, 90–92; Yegna Narayan Aiyer, 653; Kurien John, *J. sci. industr. Res.*, 1943–44, **2**, 124; *I. & S. Bull.*, 1951, **3**(3), 3].

In the preparation of crepe rubber, sodium bisulphite (0.5%) is employed as the coagulating agent. It prevents darkening during drying and produces a pale, almost white, rubber. Mercaptans have also been employed as coagulating agents. The coagulum is cut into long pieces, squeezed, sheared and masticated through a series of differentially geared corrugated rollers. It is finally rolled into sheets with a rough or corrugated surface and dried by hanging on racks in well ventilated drying rooms for a week or more; heat may be applied to hasten the drying (Grist, 92; Thorpe, X, 553).

Sole crepe rubber used for footwear is a product obtained by coagulation in two steps. A small amount of acid, insufficient to coagulate all the rubber, is added to the latex, when a coagulum containing the yellow colouring matter separates out. The latex left over is mixed with sodium bisulphite and acid, when

a second coagulum is obtained. This is processed to give sole crepe which is pale or almost white.

Lower grades of rubber constitute 10–15% of the total crop. These are: (i) *dried latex* or tree scrap found on tapping cuts and spouts ; (ii) *lump*, formed by natural coagulation in collecting cups and buckets before the latex reaches the factory ; (iii) *skimmings* from coagulation pans and tanks ; (iv) *discoloured crepe* or pieces of torn coagulum from first latex crepe or sheet ; (v) *earth scrap* from latex which overflows the tapping cut and coagulates on the soil ; and (vi) *bark scrap* or dried latex found in bark shavings removed during tapping. Grade (i) to (iv) are converted into crepe ; grade (v) and (vi) are processed to give a low grade crepe, dark in colour, often tacky (Grist, 92–94 ; Flint, 122–32 ; Fuller, loc. cit.).

*Physical properties*—The physical properties of rubber vary with temperature. Natural rubber is soft and translucent at 20° ; when chilled to 0–10°, it becomes hard and opaque ; at the temperature of liquid air, it is brittle and transparent like glass. At temperatures exceeding 25°, rubber loses elasticity and becomes sticky ; the change is reversible provided the temperature attained is not too high and the heating is not too long. Rubber melts to a viscous fluid at about 200°, and decomposes to isoprene, dipentene and complex terpenic hydrocarbons. Thermal decomposition yields liquid hydrocarbons the nature of which varies with the method of 'cracking' employed ; fuel oils, lubricating oils, rubber solvents and softeners are obtained.

Rubber is insoluble in water and is unaffected by alkalies or moderately strong acids. It is soluble in benzene, naphtha, carbon disulphide, ether, chloroform and chlorinated hydrocarbons. When rubber is dissolved in a solvent, it first swells to gel-like consistency and then forms a solution.

The elastic property of rubber is closely related to its molecular structure. A pull stretches the molecular chains (the filaments slipping past each other) and when the pull is released, the kinked configuration is restored. The resilience falls with decreasing temperature, and after attaining a minimum at *c.* −35° shows a rise. This phenomenon is associated

FIG. 43. HEVEA BRASILIENSIS—PRESSING SHEET RUBBER THROUGH ROLLERS

with the changes in the configuration of molecular chains which accompany deformation. Smoked sheet has a rebound of 64.5% at 24° ; after thorough mastication the rebound is reduced to 48%.

Rubber is amorphous in the unstretched state, but shows crystalline behaviour when kept at 0° for a long time or when stretched. During stretching, the elongated rubber molecules assume a regular or lattice structure, parallel to the direction of stretch. The size of the crystallite has been estimated to be 600Å. Rubber is shown by X-ray diffraction to be an intimate mixture of crystalline and amorphous components. The amount of crystalline rubber under the most favourable conditions of strain has been estimated by some at 80–90% and by others at 30–40%.

Highly stretched rubber possesses many characteristics of fibrous materials ; it may be readily torn along the direction of extension, but is extremely tough in the transverse direction. When frozen in liquid air and hammered, rubber splits up into fibres. When released from the highly stretched condition, rubber does not completely revert to its original length, the resulting increase in length, expressed as percentage of the original length, being called permanent set. The deformation increases with time and recovery proceeds over a considerable time. Heated rubber shows less permanent set.

Rubber is one of the best insulating and dielectric materials available. It behaves as a normal non-polar material, the dielectric constant (*c.* 2.5) approaching closely the square of the refractive index at normal temperatures. Rubber-sulphur vulcanisates are, however, polar. The electrical properties are influenced by water-soluble impurities which accompany manufactured rubber.

Some of the physical properties of raw rubber are summarised in Table 11. Other physical characteristics are: heat of combustion, 10,700 cal./g. ; thermal conductivity, 0.00032 ; $n_D^{25°}$, 1.5190 ; and optical dispersion (for wave lengths 6,563Å and 4,861Å) at 25°, 0.0330. Stretching of raw rubber is accompanied by generation of heat due to crystallisation (Joule effect) ; about 680 cal./g. are generated when stretched to 820%. The crystallisation of rubber (both raw and vulcanised) under tensile strain produces optical double refraction (Thorpe, X, 575–78 : Kirk & Othmer, IX, 817–18 ; Read, 472 ; Barron, 79, 88–115 ; Treloar, *Endeavour*, 1952, **11**, 92).

*Chemical properties*—First grade latex plantation rubber (sheet rubber and crepe rubber) contains: rubber hydrocarbon, 92–94%. Table 12 gives the non-

TABLE 11—PROPERTIES OF RAW & VULCANISED RUBBER*

| | Raw rubber | Vulcanised rubber (*a*) | Vulcanised rubber (*b*) |
|---|---|---|---|
| *Physical :* | | | |
| Tensile strength (kg./sq. cm.) | 20–40 | 275–350 | 275–350 |
| Elongation (%) | 800–1,200 | 675–850 | 550–650 |
| Hardness (Shore Durometer A) | 20–30 | 40–45 | 62–67 |
| Permanent set (after 200% elongation, 24 hr.) | 75–125 | 3–5 | 8–12 |
| Modulus of elasticity at 300% elongation (kg./sq. cm.) | 5–10 | 11–24 | 50–90 |
| Sp. gr.$^{20°}$ | 0.914 | 0.96 | 1.13 |
| *Thermal :* | | | |
| Co-efficient of linear expansion ($10^{-5}$/°C) | 15–20 | 16–19 | 12–15 |
| Specific heat (cal./g./°C) | 0.55 | 0.5 | 0.4 |
| Brittle pt (°C) | −62 to −58 | −58 to −53 | −58 to −56 |
| *Electrical :* | | | |
| Volume resistivity (Ohm × cm.) | $10^{16}$ | $10^{11}$ | |
| Dielectric strength (k.v./mm.) | 10–20 | | |
| Dielectric constant × $10^{-3}$ (1,000 cycles) | 2.5 | | |
| Power factor × $10^{-3}$ (1,000 cycles) | 2–3 | | |

* Encyclopaedia Britannica, XIX, 609.
(*a*) not loaded with pigment. (*b*) loaded with 25% carbon black + 10% softener.

TABLE 12—NON-RUBBER CONSTITUENTS OF RUBBER*
(%)

| | First latex rubber | | Low grade rubber | | | |
|---|---|---|---|---|---|---|
| | Smoked sheet | Crepe | Lump | Tree scrap | Bark scrap | Earth scrap |
| Moisture | 0.30–1.08 (av. 0.61) | 0.18 0.90 (av. 0.42) | 0.8 | 1.2 | 1.2 | 0.8 |
| Acetone extr. | 1.52–3.50 (av. 2.89) | 2.26 3.45 (av. 2.88) | 2.9 | 2.50 | 2.6 | 2.8 |
| Protein & other nitrogenous matter | 2.18–3.50 (av. 2.82) | 2.37–3.76 (av. 2.82) | .. | .. | .. | |
| Ash | 0.20–0.85 (av. 0.38) | 0.15 0.87 (av. 0.30) | 0.8 | 0.7 | 0.9 | 1.0 |
| Water extr. | | | 0.5 | 0.6 | 0.4 | 0.2 |

* Davis & Blake, 13, 31.

rubber constituents of various types of first latex and lower grade rubbers. As compared to rubbers from other plant sources (Table 13), *Hevea* rubber is characterised by low resin content (Davis & Blake, 12).

Rubber hydrocarbon, also known as caoutchouc, is colourless, odourless, transparent and elastic. It consists of long chains of isoprene units connected end to end through 1:4 linkages. The chains normally exist in a highly kinked, but fluctuating, configuration due to the free thermal rotation of constituent links about single C-C bonds. The rubber molecule contains about 5,000 units of isoprene and has an average molecular weight of 350,000; av. length, 20,000Å. The decrease in molecular weight from the latex state to the raw rubber state is due to the breakdown of the polymer which occurs in sheeting and creping operations. The isoprene units of rubber have a *cis* configuration.

Rubber forms compounds with halogens, halogen acids and metallic halides, ozone and oxides of nitrogen. Hydrogenation at elevated temperatures and pressures in the presence of a catalyst gives fully saturated hydrorubber. Rubber is oxidised by nitric acid, potassium permanganate and hydrogen peroxide. Atmospheric oxygen, especially in the presence of copper salts, causes slow degradation resulting in softening, increased solubility in solvents, and loss of strength and elasticity. Ozone renders raw rubber soft and tacky, and forms unstable ozonides.

Cyclisation of rubber is brought about by heat; it is also effected by treatment with stannic chloride and other reagents.

When heated with sulphur, rubber undergoes profound changes in its properties. This treatment, vulcanisation as it is called, has revolutionised the rubber industry. Vulcanisation is generally believed to produce cross linkages between chains at the double bonds, thus forming a continuous molecular network; it may also bring about cyclic linkages (Thorpe, X, 565–69; Kirk & Othmer, XI, 815–17; Barron, 65–86).

TABLE 13—ANALYSES OF RUBBERS FROM DIFFERENT PLANTS*
(%)

| | Rubber hydrocarbon | Resin | Protein | Ash |
|---|---|---|---|---|
| *Hevea brasiliensis* | 94 | 3 | 2 | 0.2 |
| *Castilla elastica* | 93 | 6 | 0.5 | 0.1 |
| *Landolphia thollonii* | 93 | 5 | 1 | 0.5 |
| *L. owariensis* | 93 | 6 | 0.1 | 1.0 |
| *L. kirkii* | 91 | 8 | 0.1 | 1.0 |
| *Taraxacum kok-saghyz* | 90 | 5 | 2 | 3.0 |
| *Funtumia elastica* | 88 | 8 | 3 | 0.5 |
| *Manihot glaziovii* | 88 | 4 | 6 | 1.5 |
| *Cryptostegia grandiflora* | 88 | 9 | 2 | 0.3 |
| *Ficus elastica* | 78 | 20 | 1 | 0.5 |
| *Parthenium argentatum* | 72 | 22 | 3 | 2.5 |

* Thorpe, X, 551.

*Grading*—The system adopted in India for grading raw rubber is based on the type descriptions of the Rubber Manufacturers' Association (R.M.A.) and endorsed by the Rubber Trade Association of New York. These types are recognised as universal standards by producing and consuming countries alike. The R.M.A. classification takes into account such visual characteristics as colour, uniformity, presence

of foreign particles, etc.; upper tolerance limits for copper and manganese contents (copper, 8 p.p.m.; manganese, 10 p.p.m.) have also been prescribed (*Indian Rubb. Bd Bull.*, 1952, **2**, 57; *Indian Rubb. Bull.*, No. 76, 1955, 15).

The group-wise classification of commercial grades of Indian rubber and their R.M.A. gradings are indicated below:

Group 1: R.M.A. 1X and R.M.A. 1
Group 2: R.M.A. 2, R.M.A. 3 and Cuttings No. 1
Group 3: R.M.A. 4, R.M.A. 5 and Cuttings No. 2
Group 4: Precoagulated Crepe, Pale Latex Crepe 1X, 1, 2 and 3 F.A.Q.
Group 5: Estate Brown Crepe 1X and 2X, Super 1X, Smoked Blanket and Remilled Crepe 2
Group 6: Estate Brown Crepe 3X, Remilled Crepe 3 and 4
Group 7: Flat Bark Crepe (Earth Scrap Crepe)

Table 14 gives the group-wise production of rubber in India.

The R.M.A. classification, which is based mainly on visual inspection, does not give any indication of the intrinsic quality of crude rubber. The need for evolving a system by which crude rubber could be graded according to technological properties was felt during World War II, when natural rubber came into competition with synthetic rubber. A scheme prepared in 1949 by a French technologist in Indo-China has been recently adopted in Indo-China and Malaya. According to this system, natural rubber is classified on the basis of (1) processing characteristics (based on viscosity) and (2) vulcanisation characteristics. Each of these characteristics is divided into three ranges of values, thus giving nine technical classes. Rubbers classified according to this method are called Technical Classified Rubbers (TCR). This classification is intended to supplement the R.M.A. classification (*ASTM spec. tech. Publ.*, No. 136, 1952).

*Packing*—Natural rubber is packed in bales in accordance with R.M.A. packing specifications.

TABLE 14—GROUP-WISE PRODUCTION AND CONSUMPTION OF RUBBER IN INDIA

(qty in tons; figures in brackets represent percentage of total)

| | 1952* | | 1953* | | 1954‡ | | 1955‡ | | 1956‡ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Consumption | Production | Consumption | Production | Consumption | Production | Consumption | Production | Consumption |
| Group 1 | 8,188 (41.2) | 7,941 (37.7) | 8,434 (39.9) | 5,932 (26.5) | 8,457 (39.3) | 6,845 (26.9) | 8,938 (39.8) | 6,653 (24.1) | 9,126 (39.3) | 10,157 (35.3) |
| Group 2 | 3,790 (19.1) | 4,875 (23.1) | 4,118 (19.5) | 6,030 (27.0) | 4,159 (19.4) | 8,179 (32.1) | 4,112 (18.3) | 9,527 (34.6) | 4,315 (18.4) | 7,698 (26.5) |
| Group 3 | 1,755 (8.8) | 1,029 (4.9) | 2,039 (9.7) | 3,214 (14.4) | 2,132 (9.9) | 2,712 (10.6) | 2,071 (9.2) | 2,376 (8.6) | 2,388 (10.2) | 1,194 (4.1) |
| Group 4 | 1,147 (5.8) | 732 (3.5) | 1,297 (6.1) | 955 (4.3) | 1,165 (5.4) | 1,049 (4.1) | 1,283 (5.7) | 967 (3.5) | 1,234 (5.2) | 1,226 (4.2) |
| Group 5 | 834 (4.2) | 3,310 (15.7) | 934 (4.4) | 2,451 (10.9) | 1,027 (4.8) | 2,527 (9.9) | 1,183 (5.3) | 3,228 (11.7) | 1,145 (4.8) | 2,874 (9.9) |
| Group 6 | 563 (2.8) | 1,003 (4.8) | 743 (3.5) | 1,656 (7.4) | 818 (3.8) | 2,080 (8.2) | 875 (3.9) | 2,419 (8.8) | 602 (2.5) | 2,792 (9.6) |
| Group 7 | 34 (0.2) | 119 (0.6) | 38 (0.2) | 158 (0.7) | 57 (0.3) | 143 (0.6) | 44 (0.2) | 112 (0.5) | 41 (0.2) | 100 (0.3) |
| Scrap grades | 2,323 (11.7) | 199 (0.8) | 2,353 (11.1) | 268 (1.2) | 2,235 (10.4) | 179 (0.7) | 2,407 (10.7) | 143 (0.5) | 2,809 (11.9) | 79 (0.2) |
| Sole Crepe | 671 (3.4) | 286 (1.4) | 545 (2.6) | 202 (0.9) | 605 (2.8) | 178 (0.7) | 546 (2.4) | 150 (0.5) | 480 (2.0) | 156 (0.5) |
| Latex | 558 (2.8) | 667 (3.2) | 635 (3.0) | 607 (2.7) | 838 (3.9) | 770 (3.0) | 1,022 (4.5) | 1,088 (4.0) | 1,304 (5.5) | 1,420 (4.9) |
| Unspecified | .. | 900† (4.3) | .. | 900† (4.0) | .. | 825† (3.2) | .. | 880† (3.2) | .. | 1,300† (4.5) |
| TOTAL | 19,863 | 21,061 | 21,136 | 22,373 | 21,493 | 25,487 | 22,481 | 27,543 | 23,444 | 28,996 |

* *Indian Rubb. Bd Bull.*, 1952, **2**, 55; 1953-54, **3**, 68. ‡ Data supplied by Rubber Board, India. † Estimated consumption by some manufacturers from whom returns have not been received (groups not known).

Ribbed smoked sheets are packed in rubber covered bales (size, 19 in. x 19 in. x 24 in.; volume, c. 5 cu. ft.), the prescribed maximum and minimum weights of a bale being 250 and 224 lb. net respectively. The bale is wrapped on all sides and corners with rubber of equal or higher quality. Before wrapping, the surfaces are dusted with talc to prevent sticking. One coat of R.M.A. bale coating solution is then painted on all sides and firm marks and lot identification marks are stencilled [Bocquet, *Rubb. India,* 1952, **4**(9), 17; *Indian Rubb. Bd Bull.*, 1952, **2**, 66; *Indian Rubb. Bull.,* No. 77, 1955, 12].

Other R.M.A. types of natural rubber, such as pale crepe, flat bark crepe, brown crepe, blanket crepe and smoked blanket crepe are packed in burlap or rubber batches, each batch (volume, *c.* 5 cu. ft.) weighing 224–50 lb. net (*Indian Rubb. Bd Bull.*, 1952, **2**, 66; *Indian Rubb. Bull.,* No. 77, 1955, 12).

*Marketing*—Raw rubber is marketed in the form of dry rubber (Ribbed Smoked Sheets, Pale Latex Crepe, Sole Crepe, Estate Brown Crepe) and preserved latex (Normal Latex, Creamed Latex and Centrifuged Latex). About two-thirds of the total production is marketed by managing agents after grading. Small estates sell the produce directly to manufacturers or to dealers in marketing centres. Small holders accumulate the produce to a sizeable quantity and then sell it to itinerant dealers against cash payment on the basis of weight. The quality of the product is generally not taken into account and the price offered is far less than the controlled rates. Petty merchants and dealers sell the collection to the nearest depot of a purchasing firm or take them to dealers in Kottayam, Trivandrum, Trichur or other market centres (Reddy, *Rep. Marketing Organization for Rubber, Indian Rubb. Bd,* 1950, 6; Kaimal, *Rubb. India, Spec. Conf. Number,* 1954, **6**, 27).

Rubber latex is marketed as normal latex (D.R.C., 30–40%) preserved with ammonia. The bulk of it is marketed in concentrated form, packed in iron drums or tanks. In India, creamed latex is marketed in two concentrations, D.R.C., 58–60% and 50% (Cherian, *Indian Rubb. Bd, Serial Pamphl.*, No. 2, 1949, 6).

### Utilisation

*Dry rubber*—Raw rubber as such has few important applications. Its chief uses are in making insulation tapes, shoe soles, adhesives, and erasers. The properties of rubber are greatly influenced by chemical treatment, particularly vulcanisation. Practically all the rubber goods produced for industrial use are vulcanised (Thorpe, X, 554).

For vulcanisation, the raw stock (smoked sheet or pale crepe) is masticated, plasticised and mixed with vulcanising agents, accelerators, anti-oxidants, reinforcing agents, fillers and other ingredients; the mixture is then heated to 113–130°, preferably under pressure. The nature and concentration of the ingredients, and the time and temperature of vulcanisation determine the properties of the product obtained. In the cold vulcanisation process used for thin rubber goods, thin sheets, formed from naphtha solution, are treated with sulphur monochloride dissolved in carbon disulphide.

The chief difference between raw rubber and soft vulcanised rubber is that the latter when stretched returns to its original shape and dimensions, whereas raw rubber does not. Another outstanding characteristic of vulcanised rubber is its resistance to plastic flow under a wide variety of conditions. Vulcanised rubber also differs from raw rubber in being less tacky, in having a high tensile strength, greater elongation, less hysteresis, and greater resistance to the action of solvents and heat, to tear and abrasion. Some of the physical properties of raw and vulcanised rubber are summarised in Table 11.

The electrical properties of rubber are relatively less affected by vulcanisation. The dielectric constant of vulcanised rubber (which is usually kept low) increases with increasing sulphur content to a maximum of 3.75 at 11.5% sulphur and then decreases to a minimum of 1.7 at 22% sulphur content; the dielectric constant of ebonite (32% sulphur) is 2.82. The power factor (which is also kept as low as possible) decreases until the concentration of sulphur reaches 4%, then increases rapidly to a maximum value of $93.8 \times 10^{-3}$ when the sulphur content reaches 13.5%; then decreases to $2.6 \times 10^{-3}$ at 23% sulphur and increases up to $5.1 \times 10^{-3}$ at 32%. Resistivity increases with increasing sulphur, reaches the value of $2 \times 10^{17}$ ohms at 12% sulphur, then sharply decreases to a minimum of $26 \times 10^{15}$ at 18% sulphur and again increases to $1 \times 10^{17}$ at 22% sulphur, after which it decreases slightly (*Vanderbilt Rubb. Handb.*, 1942, 32–39; Barron, 185–87).

Hard Rubber, Vulcanite, or Ebonite (resembling ebony) is a highly sulphurised rubber, containing 25–50% (usually 32%) combined sulphur. It is usually dark, but hard rubber of light colour can be prepared by selecting the compounding ingredients and adding pigments. Ebonite has the following physical charac-

teristics: sp.gr.$^{25°}$, 1.13–1.18; sp. heat, 0.331; coefficient of linear expansion $\times 10^{-5}$ (cm./°C), 7; tensile strength (kg./sq.cm.), 600–800; water absorption (%, after immersion for 315 days), 0.23–0.28; dielectric constant (1,000 cycles), 2.8–2.9; power factor (1,000 cycles), $3–8 \times 10^{-3}$; volume resistivity (ohm/cm.), $1–3 \times 10^{16}$; and dielectric strength (k.v./mm. with oil immersion), 115–149. Ebonite is hard at ordinary temperatures; it softens on warming to 60° and is reasonably flexible at 100°. It is relatively tough and non-elastic, has high impact strength and resistance to abrasion, and can be moulded, sawn, drilled, turned and polished. Ebonite has good electrical insulation properties, and is exceptionally resistant to chemical corrosion. Ebonite is available in powder and sheet form (Thorpe, X, 571; Davis & Blake, 635–52; *Indian Rubb. Bull.*, No. 77, 1955, 23).

Rubber is used for the production of a wide variety of products utilised in industries and services, and for domestic purposes. It has been estimated that about 50,000 different products are fabricated from rubber directly or indirectly. Tyres and tubes for automobiles and cycles account for about 75% of the total rubber consumption. About 6% is used for footwear (boots, shoes, heels and soles); about 4% for wire and cable insulations; among miscellaneous manufactured articles mention may be made of rubberised fabrics; motor mountings for absorbing vibrations and shocks; washers and gaskets; transmission and conveyor belting; garden hose, fire hose, and hose for gasoline; pneumatic tools; paints; sports goods, such as football, basket ball, tennis ball and polo ball; household and hospital supplies, such as sheets, hot water bags, ice bags, surgeon's gloves, bathing caps and prophylactics; toys such as balls, dolls, and balloons; erasers and rubber bands; and adhesives. Metals are coated with rubber to protect them from wear and corrosion. Sponge rubber from foamed latex finds use in cushioning, seating and bedding. Elastic fabrics are made from latex threads. Ebonite finds application in electrical and radio engineering industries and for protective lining in chemical plant. It is also employed in the fabrication of battery boxes, fountain pen barrels, tobacco pipe stems, telephones, combs and dentures.

*Latex*—Natural rubber latex, in preserved and concentrated forms, finds many commercial applications. Compounded latex is largely replacing rubber solutions for the manufacture of such articles as balloons, gloves, contraceptive appliances, finger stalls, and teats. It is estimated that in U.S.A., the consumption of natural latex has doubled from 1948 to 1952. Over 65% of the latex is used in the manufacture of foam rubber and the rest for dipped goods, fabric coatings, impregnation and moulded goods.

The use of latex in place of dry rubber has certain advantages. Latex does not require mastication and needs fewer forming machines. The cost of production is comparatively low. Also articles made from vulcanised latex possess higher tensile strength and elongation, since the rubber particles remain intact and are not broken by mastication as in the treatment of dry rubber. The use of organic solvents for bringing dry rubber into solution is avoided and health and fire hazards are minimised. Higher outturn is possible in the manufacture of goods when latex is employed. Lastly, latex is suitable for the production of certain kinds of articles which are extremely difficult to produce from rubber solutions.

Uncured latex finds a few applications in industry: it is used as an adhesive in footwear manufacture, as pressure-activated sealing for envelopes and for hermetic sealing of food containers. The bulk of latex goods is made from vulcanised latex. The latex is mixed with compounding ingredients similar to those used in processing dry rubber, the ingredients being added in the form of solutions or colloidal dispersions for obtaining a homogeneous and stable mixture. Compounded latex is converted into rubber goods by dipping, coating, extrusion, foaming or electro-deposition. Solidified articles are finally vulcanised (Thorpe, X, 562–65; Kirk & Othmer, XI, 942–45; Stevens, 49–60; Stevens & Stevens, 55–83).

*Reclaimed rubber*—Reclaimed rubber prepared from discarded rubber products and rubber scrap, mainly worn out automobile tyres and inner tubes, resembles crude rubber in its behaviour towards compounding ingredients, differing only in the degree of response to various types of treatment. It is lower in cost than raw rubber, is easier to process, and generally has better resistance to ageing. It is used alone or in admixture with raw rubber in the manufacture of heels, soles, mechanical rubber goods, tyres, dispersions and adhesives for use in fabric dipping, carpet backing, flooring, etc., and hard rubber used for battery containers, tubes and rods (Read, 479; Barron, 268–93; Stafford & Wright, *Indian Rubb. Bull., Spec. Number*, 1954, 63).

*Rubber derivatives* — Rubber derivatives are

prepared from unvulcanised rubber by treatments involving addition, substitution and cyclisation reactions. Commercial chlorinated rubbers, such as Alloprene, Tornesit, and Parlon (chlorine, 65–66%) are obtained by reacting rubber with carbon tetrachloride; they are resistant to chemical action and are used in corrosion-resistant paints and lacquers. Pliofilm (chlorine, 30–35%), a rubber hydrochloride, obtained by passing dry hydrogen chloride into 6% rubber cement, is used as packing material for textiles, paper products, foodstuffs, etc.; it is transparent, flexible, impervious to water vapour and possesses high tear resistance. Cyclised rubbers, prepared by treating rubber with stannic chloride, chlorostannic acid, sulphuric acid, organic sulphonyl chloride or certain other reagents, are used as rubber-to-metal adhesives, plastic base for chemical-resistant paints, and shoe soling. They are thermoplastic and possess properties intermediate between rubber and gutta percha (from *Palaquium* sp.) [Thorpe, X, 566–68; Rogers, II, 1483; Kapur & Ramakrishnan, *Rubb. India*, 1955, **7**(3), 47].

*Other rubbers*—Besides *Hevea*, several plants have been tried from time to time as sources of rubber (Table 13). Of these, the Russian Dandelion (*Taraxacum kok-saghyz* Rodin) and the Mexican Guayule (*Parthenium argentatum* A. Gray) may be mentioned. The former is grown on *c.* 2,000,000 acres of land in the Soviet Union and rubber of good quality is reported to be obtained from the roots of the plant. Guayule rubber is extracted from the whole plant; it is of inferior quality. Other rubber-producing plants of local importance are: *Manihot glaziovii* Muell. Arg. (Ceara rubber), *Castilla elastica* Cerv. (Castilla or Panama rubber), *Ficus elastica* Roxb. (Assam rubber), *Hancornia speciosa* Gomez (Mangabeira rubber) and *Funtumia elastica* Stapf (Lagos silk rubber) (Hill, 140–46; Schery, 195–200; Thorpe, X, 550–51).

*Synthetic rubbers*—True substitutes of natural rubber have not been produced, but for some years, natural rubber has been facing increasing competition from synthetic copolymers with rubber-like properties. In U.S.A., and probably U.S.S.R., more synthetic rubber is consumed than natural rubber. Even though synthetic rubber has several advantages over natural rubber as regards strength, adhesion, and resistance to oils, oxidising agents, light and heat, they do not possess the essential qualities of natural rubber, e.g. elasticity, and low temperature flexibility. Synthetic rubbers are at present used mainly to supplement natural rubber; in certain fields, synthetic rubbers are exclusively employed.

*GR-S*, a general purpose synthetic rubber is a butadiene-styrene copolymer, with pronounced resistance to cracking and abrasion. It is preferred to natural rubber in the production of certain tyre treads, mechanical goods and wire insulation. Other synthetic rubbers of commerce are: *GR-A* or *Buna N* (copolymer of butadiene and acrylonitrile) used in applications requiring oil-resistance; *GR-I* or *Butyl Rubber* (copolymer of isobutylene and isoprene) valued for its low permeability to gases and high resistance to chemicals, widely used for making inner tubes; *GR-M* or *Neoprene* (polymer of chloroprene) resistant to oils, chemicals and flame, stable to light and ageing, and valued for hose, gaskets, belting, moulded goods, coated fabrics, and adhesives; *Thiokols* (prepared by reaction of an organic dichloride and a sodium polysulphide) valued for outstanding oil- and solvent-resistance and used for moulded products, wire covering, and coatings; *Silicone Rubbers* (based on silicone) valued for their heat resistance, non-sticking and excellent surface properties, retention of flexibility, resilience and tensile strength over a wide range of temperatures (−100° to 500°F.), and useful for jet engine components, aircraft ducting, gaskets, seals and diaphragms, valve sets, etc. [Brady, 690–96; Kirk & Othmer, XI, 827–56; Street, *Indian Rubb. Bull.*, No. 74, 1955, 10; Shanker, *Rubb. India*, 1955, **7**(2), 9; Modak, ibid., 1954, **6**(1), 14].

Prior to World War II, production of synthetic rubber was mainly confined to Germany and Soviet Union. It was only after the Japanese occupation of South-east Asia, that rapid developments in synthetic rubber production took place in U.S.A., Canada, U.S.S.R., and other European countries.

### Production and Trade

The world production of natural rubber increased from about 45,000 tons in 1900 to 1,913,000 tons in 1955. The major producing countries are Indonesia (38%), Malaya (33%), Thailand (7%), Ceylon (5%) and Indo-China (5%) (Table 1). India occupies the ninth place among the rubber producing countries and contributes about 1.2% to the total production. About 91% of the production within India is concentrated in Kerala, 7% in Madras and 2% in Mysore (Table 2).

*Acreage*—The acreage under rubber in India and neighbouring countries has shown marked variations

in consonance with fluctuations of prices in world markets. The high prices which rubber fetched during the early years of the century gave an impetus to rubber cultivation and many new plantations were opened up in India and other countries. The extension of rubber cultivation continued till 1929, when as a result of the general trade depression, the prices slumped and the plantation industry suffered a set back. An International Rubber Regulation Agreement was signed in 1934 by the major rubber growing countries by which production, export and import were regulated. Prices of rubber began to recover and prospects for fresh plantings improved. With the outbreak of hostilities in South-east Asia and the occupation of Malaya, Indonesia and Indo-China by the Japanese in 1942, supplies of rubber to western markets dwindled. To meet the demand, the international agreement was terminated and rubber planting was encouraged. In India, in 1943 alone, over 15,000 acres were planted.

While the earlier plantings in India were mostly made with unselected seedling rubber trees, a considerable proportion of post-war planting was made with high-yielding types, particularly budgrafts and clonal seedlings.

The Government of India passed the Indian Rubber Control and Production Order, 1942, constituting the Indian Rubber Production Board with the object of encouraging and ensuring increased production of rubber by all possible means. The Rubber (Production and Marketing) Act, 1947 was passed to replace the Indian Rubber Control and Production Order of 1942, and a statutory organisation, the Indian Rubber Board, was constituted to look after the interests of rubber producers, through such measures as price control, import restrictions and other measures. The Board was reconstituted in August 1955 under a new Act, the Rubber (Production and Marketing) Amending Act, 1954, and a research station was set up at Kottayam to help the industry [Isaac & Naidu, *Indian Rubb. Bd, Serial Pamphl.*, No. 1, 1 ; *I. & S. Bull.*, 1950, **3**(3), 3 ; Menon, *Rep. Rubb. Bd*, 1955-56, 14 ; *Rubb. India*, 1952, **4**(11), 3 ; *Indian Rubb. Bull.*, No. 48, 1953, 22 ; *Rubber in India*, 1951 & 1952 ; *Rubb. Bd Bull.*, 1956, **4**(1), 5].

Under the provisions of the new Act, all rubber growers and dealers are required to register their names with the Indian Rubber Board. A license from the Board is required for growing any kind of rubber or for carrying out new planting or replant-

TABLE 15—PRODUCTION & CONSUMPTION OF NATURAL RUBBER IN INDIA*
(tons)

| | Production | Consumption† |
|---|---|---|
| 1939 43 (av.) | 15,923 | 11,267 |
| 1944 48 (av.) | 16,209 | 15,620 |
| 1949–53 (av.) | 17,867 | 20,558 |
| 1954 | 21,493 | 25,487 |
| 1955 | 22,481 | 27,543 |
| 1956 | 23,444 | 28,996 |

* *Indian Tariff Bd, Rep. on the Prices for Raw Rubber*, 1951, appx 22 & 23 ; *Indian Rubb. Bd Bull.*, 1953–54, **3**, 101 ; *Rubb. Bd Bull.*, 1956–57, **4**(4), 86. † Consumption includes both indigenous and imported rubber.

TABLE 16—CONSUMPTION OF NATURAL RUBBER IN PRINCIPAL COUNTRIES*
(thousand tons)

| | 1950 | 1951 | 1952 | 1953 | 1954 | 1955†† |
|---|---|---|---|---|---|---|
| U.S.A. | 720 | 454 | 454 | 553 | 596 | 635 |
| United Kingdom | 220 | 234 | 197 | 220 | 239 | 246 |
| Soviet Union** | 83 | 63 | 123 | 42 | .. | n.a. |
| France | 103 | 119 | 122 | 115 | 127 | 134 |
| West Germany | 79 | 92 | 93 | 106 | 130 | 148 |
| China** | 70 | 73 | 24 | 60 | 62 | n.a. |
| Japan | 60 | 59 | 68 | 89 | 89 | 88 |
| Canada | 46 | 44 | 34 | 37 | 42 | 44 |
| Italy† | 37 | 50 | 44 | 47 | 55 | n.a. |
| Australia | 34 | 36 | 28 | 33 | 43 | 45 |
| Union of S. Africa† | 21 | 27 | 19 | 25 | 29 | 27 |
| India | 18 | 22 | 21 | 22 | 25 | 28 |
| Sweden | 14 | 19 | 19 | 19 | 25 | n.a. |
| Belgium | 12 | 18 | 15 | 18 | 20 | n.a. |
| Brazil | 23 | 26 | 28 | 32 | 38 | 39 |
| Argentina | 17 | 25 | 13 | 21 | 23 | n.a. |
| Czechoslovakia | 23 | 11 | 20 | 17 | 22 | n.a. |
| New Zealand | 5 | 8 | 3 | 7 | 8 | n.a. |
| TOTAL‡ | 1,705 | 1,498 | 1,455 | 1,630 | 1,765 | 1,734 |

* *Plantation Crops*, Commonwealth Econ. Comm., 1956, Table 102. ** Estimated. † Net imports. ‡ Including figures for countries not shown. n.a. not available. †† *Rev. Commonwealth Raw Materials*, Vol. 1, Commonwealth Econ. Comm., 1958, Table 125.

ing. Similarly, a dealer should get a license to deal in raw rubber or to acquire raw rubber for the purpose of manufacture or for sale. In order to help development plans, a cess at the rate of Rs. 6.25 per 100 lb. is being collected from August 1955 by the Rubber Board, particularly for subsidising replanting. Subsidy is to be granted on a slab basis, depending upon the size of the holdings [*Indian Tariff Bd, Rep. on the Prices for Raw Rubber*, 1951, 37; *Indian Rubb. Bull.*, No. 73, 1955, 12; *Rubb. Bd Bull.*, 1956, **4**(1), 8].

*Production*—The production of rubber in India has gone up markedly since 1951 as a result of the increased yield per acre from new areas planted during 1942–46 and replantings with improved materials. From an annual production of 12,500 tons of rubber in 1939, the production increased to 23,444 tons in 1956 (Table 15). The production is insufficient to keep pace with the growing demand of the domestic manufacturing industry (Kaimal, *Rubb. India, Spec. Conf. Number*, 1954, **6**, 27).

The Plantation Inquiry Commission appointed by the Government of India in 1954 has examined the requirements of the industry and recommended that: an area of 1.2 lakh acres of land should be brought under high-yielding rubber trees by 1965, by replanting 70,000 acres of existing area and newly planting 50,000 acres; the area should be equally divided between the small holders and the large estates; and co-operative organisations should be formed, to help small growers with long term and short term loans, services for replanting and new planting and for processing their latex (Kaimal, *Rubb. India, Spec. Conf. Number*, 1954, **6**, 27; *Rep. Plantation Inquiry Commission, pt III, Rubber*, Govt. India, 1956).

*Consumption*—Table 16 gives the consumption of natural rubber in the principal countries of the world. U.S.A. is the largest consumer followed by U.K., West Germany and France. Rubber producing countries in South-east Asia consume little rubber and export the bulk of their production.

Unlike other producing countries in South-east Asia, India is both a producer and a consumer of rubber. The manufacture of rubber goods in India is of recent origin and the consumption of natural rubber by the domestic industry has increased from 7,000 tons in 1939 to 28,996 tons in 1956 (Table 15). The consumption is expected to reach 40,000 tons by 1960, but despite the present plan of replanting 70,000 acres with improved planting materials, the production is not likely to exceed 27,000 tons.

TABLE 17—EXPORTS OF RUBBER FROM INDIA
(qty in thousand lb. and val. in thousand Rs.)

| | Qty exported to | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | U.K. | Germany | France | Italy | Ceylon | Malaya | U.S.A. | Others | Qty | Val. |
| 1929/30-1933/34 (av.) | 7,069 | 195 | 244 | 15 | 3,278 | 5,572 | 701 | 368 | 17,442 | 7,863 |
| 1934/35–1938/39 (av.) | 8,988 | 1,888 | 349 | 807 | 3,087 | 4,832 | 1,983 | 1,729 | 23,663 | 8,282 |
| 1944 45 | 6,720 | .. | .. | .. | .. | .. | .. | .. | 6,720 | 5,110 |
| 1945–46 | 586 | .. | .. | .. | .. | .. | 4,480 | .. | 5,066 | 3,759 |
| 1946–47 | .. | .. | .. | .. | .. | .. | .. | .. | 670 | 503 |
| 1947–48 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 1948–49 | .. | .. | .. | .. | .. | .. | .. | 13† | 13 | 11 |
| 1949–50 | 960 | .. | .. | .. | .. | .. | .. | 883§ | 1,843 | 127 |
| 1950–51 | 1,475 | .. | .. | .. | 3 | .. | 571 | 67** | 2,116 | 1,987 |
| 1951–52 | 317 | .. | 18 | .. | .. | .. | .. | .. | 335 | 946 |
| 1952–53 | 188 | .. | .. | .. | . | .. | .. | 21‡ | 209 | 428 |
| 1953–54 | 122 | .. | .. | .. | .. | .. | .. | 9 | 131 | 252 |
| 1954–55 | 48 | .. | .. | .. | .. | .. | .. | .. | 48 | 85 |
| 1955–56 | .. | .. | .. | .. | .. | .. | .. | .. | 28 | 57 |

† Export to Iran. ** Export to Canada. § Export to Japan (646.8) & West Pakistan (236.5). ‡ Export to East Pakistan.

Indigenous production is being augmented by imports of natural and synthetic rubbers to meet the demands. 614 and 2,806 tons of synthetic rubber were imported in 1955 and 1956 respectively; of these imports, 107 and 2,409 tons were consumed during the same period. To meet the shortage, it is planned to start a synthetic rubber plant to produce annually 5,000–10,000 tons of rubber (*Indian Tariff Bd, Rep. on the Prices for Raw Rubber*, 1951, 26; Banerjee, *Indian Rubb. Bull., Spec. Number*, 1954, 26).

*Export*—During the first three decades of the present century, practically the entire production of raw rubber in India was exported, as there was no rubber manufacturing industry in the country. At present, there is a ban on exports of raw rubber, except sole crepe, which is produced in excess of the internal demand. Sole crepe is exported against quotas fixed each year by the Government, on the recommendation of the Indian Rubber Board. U.K. and U.S.A. are the principal importers of Indian rubber. Since

TABLE 18—IMPORTS OF RUBBER INTO INDIA
(qty in thousand lb. and val. in thousand Rs.)

| | Qty imported from | | | | | Total | |
|---|---|---|---|---|---|---|---|
| | Ceylon | Burma | Malaya & Singapore | U.S.A. | Other | Qty | Val. |
| 1929/30–1933/34 (av.) | 355 | | 233 | .. | 63 | 651 | 194 |
| 1934/35–1938/39 (av.) | 639 | 2,233 | 170 | .. | 115 | 3,157 | 846 |
| 1944–45 | (a) | | .. | 71 | .. | 71 | 19 |
| 1945–46 | .. | | .. | 138 | .. | 138 | 41 |
| 1946–47 | 211 | | 2 | 155 | (a) | 368 | 246 |
| 1947–48 | 2,003 | 45 | 1,232 | 565 | 3 | 3,848 | 2,049 |
| 1948–49 | 2,924 | | 11,881 | 574 | 179 | 15,558 | 10,146 |
| 1949–50 | 558 | | 1,928 | 4 | 382 | 2,872 | 1,705 |
| 1950–51 | 3,503 | | 6,987 | 16 | 1,474 | 11,980 | 30,087 |
| 1951–52 | 1,894 | | 7,729 | 285 | 1,257 | 11,165 | 24,581 |
| 1952–53 | 292 | | 6.024 | 105 | 1,152 | 7,573 | 9,264 |
| 1953–54 | 56 | | 3 | 247 | 1,185 | 1,491 | 879 |
| 1954–55 | 112 | | 7,550 | 310 | 2,542 | 10,514 | 10,349 |
| 1955–56 | 150 | | 8,575 | 2,667 | 3,684 | 15,076 | 19,557 |

(a) Below 500 lb.

TABLE 19—COMPARATIVE PRICES OF RUBBER IN INDIAN AND WORLD MARKETS*
(price per lb.)

| | London No. 1 R.S.S. (sh. d.) | New York No. 1 R.S.S. (U.S. cents) | Singapore No. 1 R.S.S. (Straits cents) | Colombo No. 1 R.S.S. (Ceylon cents) | India R.M.A. 1 (Rs.) |
|---|---|---|---|---|---|
| 1950 | 2 9$\frac{9}{32}$ | 41.10 | 108.18 | 155.4 | 1.28 |
| 1951 | 4 2$\frac{27}{32}$ | 59.07 | 169.55 | 214.7 | 1.28 |
| 1952 | 2 4$\frac{11}{32}$ | 38.57 | 96.07 | 137.7 | 1.38 |
| 1953 | 1 7$\frac{29}{32}$ | 24.23 | 67.44 | 135.2 | 1.38 |
| 1954 | 1 8$\frac{3}{16}$ | 23.64 | 67.30 | 110.9 | 1.38 |
| 1955 | 2 9$\frac{9}{16}$ | 39.14 | 114.16 | 128.2 | 1.50 |
| 1956 | 2 4$\frac{19}{32}$ | 34.17 | 96.76 | 144.7 | 1.56 |
| 1957 | 2 2$\frac{3}{32}$ | 31.15 | 88.75 | 114.7 | 1.56 |

* *Indian Rubb. Statist.*, 1950, 3; *Rubb. in India*, 1951, 1952, 1953 & 1954; *Rubb. Statist. Bull.*, 1957, **11**(7), 38.

1951–52, U.K. has been absorbing practically all the exports from India (Table 17) (*Indian Rubb. Statist.*, 1950, 6 ; *Indian Tariff Bd, Rep. on the Prices for Raw Rubber*, 1951, 34).

*Import*—Imports of rubber into India by manufacturers of rubber products were being permitted since 1947, on the basis of the dry rubber content (D.R.C.) of rubber goods exported by them ; imports are now permitted on the overall shortage of rubber in the country. Based on estimates of indigenous production and consumption worked out by the Rubber Board, licenses are issued for import on an *ad hoc* basis for six grades, viz. crepe rubber other than sole crepe, sheet rubber, scrap rubber latex, and reclaimed rubber (Table 18) [*Indian Tariff Bd, Rep. on the Prices for Raw Rubber*, 1951, 34 ; *Indian Rubb. Statist.*, 1950, 6 ; *Rubb. India*, 1953, **5** (11), 3 ; Banerjee, *Indian Rubb. Bull., Spec. Number*, 1954, 26].

*Prices*—Prices of all grades of rubber produced in India are controlled since 1942. The prices are fixed f.o.b. Cochin and prices at other places bear a relation to Cochin prices (Table 19). From April 1950, world prices became abnormally high due to the outbreak of the Korean war and the consequent drive for stock-piling rubber, particularly in U.S.A. and U.S.S.R. In view of the disparity between prices in India and foreign countries, the controlled price for R.M.A. 1 rubber was raised in 1951 and the maximum price fixed at Rs. 128 per 100 lb. The price was revised in 1952 to Rs. 138 per 100 lb. and again in 1955 to Rs. 150 per 100 lb. The maximum price was raised to Rs. 155.75 with effect from September 23, 1955. A schedule of the maximum and minimum prices for various grades of rubber as fixed by the Government of India and in force at present is given in Table 20. The present world prices of rubber are somewhat lower than Indian prices [*Indian Tariff Bd, Rep. on the Prices for Raw Rubber*, 1951, 20, 25, 26, 40–43 ; *First Annu. Rep. Tariff Commission*, 1952–53, 32 ; *Tariff Commission, Rep. on the Revision of Raw Rubber*, 1952 ; *Rubb. India*, 1952, **4**(8), 7, 21 ; ibid., 1952, **4**(10), 4, 15, 27 ; ibid., 1955, **7**(3), 12].

### Rubber Seed and Seed Oil

The seeds of *H. brasiliensis* resemble castor seeds in appearance ; they are larger and heavier (wt. of seed, 2–4 g.). The kernels (50–60% of the seed) possess a flavour resembling that of hazelnut. Analysis of the kernel gave the following values: moisture, 8.5 ; crude protein, 17.63 ; ether extr., 48.50 ; total carbohydrates, 22.89 ; ash, 2.48 ; calcium, 0.12 ; and phos-

TABLE 20—CONTROLLED MAXIMUM AND MINIMUM PRICES (F.O.B. COCHIN) OF RUBBER*

| | Rs. per 100 lb. Max. | Min. |
|---|---|---|
| Group 1 | | |
| R.M.A. 1X | 155.75 | 154.75 |
| R.M.A. 1 | 155.75 | 154.75 |
| Group 2 | | |
| R.M.A. 2 | 154.25 | 153.25 |
| R.M.A. 3 | 152.75 | 151.75 |
| Cuttings No. 1 | 145.25 | 144.25 |
| Group 3 | | |
| R.M.A. 4 | 149.25 | 148.25 |
| R.M.A. 5 | 145.25 | 144.25 |
| Cuttings No. 2 | 139.25 | 138.25 |
| Group 4 | | |
| Precoagulated Crepe | 161.25 | 160.25 |
| Pale Latex Crepe 1X | 159.25 | 158.25 |
| Pale Latex Crepe 1 | 157.25 | 156.25 |
| Pale Latex Crepe 2 | 156.25 | 155.25 |
| Pale Latex Crepe 3 FAQ | 155.25 | 154.25 |
| Group 5 | | |
| Estate Brown Crepe Super 1X | 151.25 | 150.25 |
| Estate Brown Crepe 1X | 147.25 | 146.25 |
| Estate Brown Crepe 2X | 144.25 | 143.25 |
| Smoked Blanket | 147.25 | 146.25 |
| Remilled Crepe 2 | 139.75 | 138.75 |
| Group 6 | | |
| Estate Brown Crepe 3X | 136.25 | 135.25 |
| Remilled Crepe 3 | 134.25 | 133.25 |
| Remilled Crepe 4 | 128.75 | 127.75 |
| Group 7 | | |
| Flat Bark | 120.25 | 119.25 |
| 5% Normal Latex (excluding cost of container) | 156.75 + a premium of Rs. 17.50 per 100 lb. of D.R.C. | 155.75 + a premium of Rs. 17.50 per 100 lb. of D.R.C. |
| 50 to 55% Conc. Latex (excluding cost of container) | 156.75 + a premium of Rs. 43.00 per 100 lb. of D.R.C. | 155.75 + a premium of Rs. 43.00 per 100 lb. of D.R.C. |

* *Rubb. Bd Bull.*, 1956, **4** (1), 27.

J. sci. industr. Res., 1947, **6**(5), suppl., 64; Redgrove, *Gdnrs' Chron.*, 1932, **91**, 124; Guenther, VI, 173; Nicholls & Holland, 610].

Musk seeds, also known as Ambrette seeds and Grains-d'Ambrette, possess a delicate musk-like odour and are valued for the volatile oil present in the seed coat. The seeds contain: moisture, 11.4; protein, 2.30; starch, 13.35; crude fibre, 31.46; and fatty oil, 14.5%; volatile oil (0.2–0.6%), a resin and a bitter substance are present (Krishna & Badhwar, loc. cit.; *Chem. Abstr.*, 1948, **42**, 3912; Wehmer, II, 756).

Musk Seed Oil or Ambrette Seed Oil, which is the name by which the volatile oil is known, is extracted by steam-distillation of crushed seeds and used in high grade perfumery. The crude oil (concrete) is semi-solid at ordinary temperatures and contains a high percentage of fatty acids, chiefly palmitic acid. It is incompletely soluble in alcohol and tends to become rancid on keeping. For use in perfumery, the fatty acids are removed by treatment with dilute alcohol or by precipitation as calcium or lithium soaps, and a liquid oil (absolute) is obtained which is six times as strong as the crude product (Guenther, VI, 173; Redgrove, loc. cit.; Poucher, I, 35).

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FIG. 46. HIBISCUS ABELMOSCHUS—FRUITING BRANCH

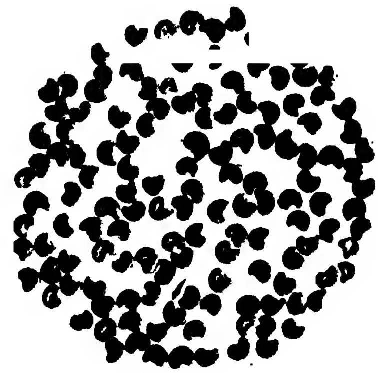

FIG. 47. HIBISCUS ABELMOSCHUS—SEEDS

Musk seed oil is also prepared by extraction with benzene; petroleum ether and alcohol may also be employed as solvents. The concrete obtained is of a resinous nature and an absolute with a remarkably persistent odour is prepared from it. Extraction with petroleum ether yields 10–14% of a resinoid, of which 80% is soluble in alcohol (Poucher, I, 35; Naves & Mazuyer, 262).

The crude product obtained by the steam-distillation of crushed seeds has a variable melting point depending upon the concentration of fatty acids. The characteristics of the concrete and the absolute are as follows: *concrete*—sp. gr.$^{40°}$, *c.* 0.89, sp. gr.$^{50°}$, *c.* 0.88; acid. val., 75–140; ester val., 56–130; insol. in 10 vol. of 90% alcohol; *absolute*—sp. gr.$^{15°}$, 0.905–0.917; $[\alpha]_D$, up to +1.6° (seldom *l*-rotatory, up to −2.4°); $n^{20°}$, 1.474–1.480; acid val., 0.4–2.5; ester val., 137–190; sol. in 2.5–8 vol. or more of 80% alcohol. 'Pure' specimens of liquid ambrette seed oil, examined by Fritzsche Brothers, Inc., New York, gave the following characteristics: sp. gr.$^{15°}$, 0.902–0.920; $[\alpha]_D$, +0.2° to +2.8°; $n^{20°}$, 1.4695–1.4768; acid val., 2.8 (max.); ester val., 143.7–196.0; ester val. after acetylation, 206.3–213.7; sol. in 0.5 vol. of 90% alcohol, often opalescent with more; sometimes sol. in 2–4 vol. of 80% alcohol or more (Guenther, VI, 174–75; Finnemore, 507).

The main constituent of the oil is a sesquiterpene alcohol, farnesol ($C_{15}H_{26}O$; 0.12% on the wt. of seed). The characteristic musk-like odour is due mainly to the presence of a ketone, ambrettolide ($C_{16}H_{28}O_2$; b.p., 154–56°/1 mm.; sp. gr.$^{20°}$, 0.9580; $n_D^{20°}$, 1.4815), a lactone of ambrettolic acid (16-hydroxy-7-hexadecenoic acid, $C_{16}H_{30}O_3$; m.p., α-isomer 53–55°,

$\beta$-isomer 26–27°) ; on hydrogenation, ambrettolic acid is converted into dihydroambrettolic acid ($C_{16}H_{32}O_3$ : m.p., 92–93°) which is identical with juniperic acid. Ambrettolide is present in the crude oil to the extent of 0.3% and is a colourless viscous liquid ; the presence of acetic and ambrettolic acids in ester forms has been reported. Furfural is present in the water condensate obtained by steam-distillation (Guenther, VI, 175 ; Wehmer, II, 756 ; West *et al.*, 201 ; Heilbron & Bunbury, I, 61).

The absolute is used as an adjunct in high grade perfumes and is dosed most carefully on account of its powerful persistent odour. Ambrettolide (natural or synthetic) is an expensive concentrated perfume used in traces as an exalting agent. It has an odour more penetrating than the absolute, but the latter has a smoother aroma. The concrete may be used in cosmetics. Musk seed fragrance though resembling that of animal musk, is essentially floral in character, and the faecal note which is sometimes seen in animal musk is absent (Guenther, VI, 175 ; West *et al.*, 201 ; Redgrove, loc. cit.).

The fatty oil extracted from the seeds is greenish yellow in colour. It solidifies gradually on exposure to air and gives a positive reaction in the Halphen test. It has the following characteristics: $n_D^{40°}$, 1.4641 ; acid val., 19.87 ; sap. val., 198.8 ; iod. val., 65.1 ; and Crismer val., 48° (Dymock, Warden & Hooper, I, 210 : *Chem. Abstr.*, 1942, **36**, 1203 ; Adriaens, 194).

Musk seeds are used in perfumery for imparting a musky odour to sachets and hair powder. In Africa they are pounded with cloves and other scented materials for use as body perfume. The Arabs are reported to use the seeds as a flavouring agent for coffee. In India, they are mostly employed as an adulterant for animal musk and in perfumes. The seeds possess insecticidal properties and are dusted, after reducing to powder, over woollen garments for protection against moths (Nicholls & Holland, 610 ; Dalziel, 126 ; Burkill, I, 1164 ; Redgrove, loc. cit. ; Wren, 244).

The seeds are used as tonic, carminative, stomachic, stimulant and anti-spasmodic, and administered in the form of tincture. They are useful in hysteria and other nervous troubles and as an inhalation for dryness of throat. A paste made from the seeds with milk is applied for itches. Leaves and roots are employed in Malaya for poulticing (Dalziel, 126 ; Kirt. & Basu, I, 331 ; Nadkarni, I, 627 ; Burkill, I, 1164 ; Wren, 244 ; Quisumbing, 573).

Tender leaves and shoots are reported to be eaten in soups ; green pods are used as vegetable in Zanzibar and Pemba. The mucilage of roots is employed for sizing paper in China ; that of leaves for clarifying sugar juice in northern India. Extracts of the upper parts of the plant and fruits show insecticidal toxicity (Dalziel, 126 ; Burkill, I, 1164 ; Williams, 296 ; Heal *et al.*, *Lloydia*, 1950, **13**, 89).

The stem bark yields a jute-like fibre (cellulose content, 78%). The strength of the fibre is not affected by wetting and though suitable for cordage, it is not known in the fibre trade (Fl. Assam, I, 144 ; Adriaens, 194 ; Haarer, 159).

**H. cannabinus** Linn. BIMLI OR BIMLIPATAM JUTE, AMBARI HEMP, DECCAN HEMP, KENAF, MESTA

D.E.P., IV, 231 ; C.P., 630 ; Fl. Br. Ind., I, 339 ; Haarer, 3–10.

SANS.—*Nalita* ; HINDI *Ambari*, *patsan*, *pitwa* ; BENG. *Mestapat* ; MAR. *Ambadi*, *ambada* ; GUJ. –*Ambari*, *sheria* ; TEL. –*Gogu*, *gonkura*, *gaynaru* ; TAM.—*Pulichhai*, *pulimanji*, *kasini* ; KAN. *Pundi* ; MAL.– *Kanjaru* ; ORIYA—*Kanuriya*.

BIHAR—*Kudrum*, *dare kudrum* ; PUNJAB– *Sankokla*.

An erect herbaceous annual with straight, slender, glabrous or prickly stem, 8–12 ft. high ; lower leaves cordate, upper leaves deeply palmately 5–7 lobed ; lobes oblong-lanceolate, sinuous, denticulate ; flowers axillary, large, 3–4 inches in diam., yellow with crimson centre ; capsules globose, pointed, bristly ; seeds large, brown, nearly glabrous.

The plant is apparently indigenous to India ; some consider it to be a native of tropical Africa, where numerous types are found growing wild. In India, it has been under cultivation since long and is found distributed throughout the country up to an elevation of 3,000 ft. in the lower Himalayas ; in many localities, it is an escape from cultivation.

The plant is cultivated mainly as a fibre crop in the drier tracts of Deccan, comprising Andhra Pradesh, parts of Mysore, Bombay, Madhya Pradesh, and Bihar. In other areas, it is cultivated on a limited scale, as a supplementary crop in mixture with others. The important centres of cultivation for fibre purposes are: Srikakulam, Visakhapatnam, Krishna and Guntur districts in Andhra ; Coimbatore and S. Arcot in Madras ; Belgaum, Bijapur and Dharwar in Mysore ; and Sholapur, W. Khandesh, E. Khandesh, and Thana in Bombay. Outside India, particularly in countries where conditions for jute cultivation are not favourable, attempts have been made to cultivate the plant and success has been reported from U.S.S.R.,

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FIG. 48. HIBISCUS CANNABINUS—CROP

S. Africa and parts of Central and North America. The plant is also grown in Java, Philippines, Korea, China and Formosa (Howard & Howard, *Mem. Dep. Agric. India, Bot.*, 1911, **4,** 9; Sircar, *Misc. Bull. Indian Coun. agric. Res.*, No. 66, 1948, 30; McCann, *U.S. Dep. Agric. Bibliogr. Bull.*, No. 17, 1952; Haarer, 8-9; McGregor, *Jute Bull.*, 1952–53, **15,** 33; Ray, ibid., 1953–54, **16,** 257; Bally, *Ciba Rev.*, No. 108, 1955, 3901; Kar, 105).

Numerous varieties of *H. cannabinus* are found in cultivated and semi-wild states in various producing countries. They differ from one another in the colour and thickness of the stem, leaf form, flower colour and certain agricultural characteristics, such as adaptability to different soils and climates, vigour of growth, and rate of maturation. From a study of a large number of variants collected all over India, 5 distinct varieties comprising eight agricultural types have been isolated at Pusa (Bihar). These are: var. *simplex* (Type 1), var. *viridis* (Type 2), var. *ruber* (Type 3), var. *purpureus* (Types 4 & 5) and var. *vulgaris* (Types 6, 7 & 8). Among these, Type 3 and Type 6 (renamed *N.P.* 3 and *N.P.* 6) are best suited for fibre purposes. *N.P.* 3 with general vigour and capacity to grow and set seed under comparatively unfavourable conditions is well adapted for conditions obtaining in Bihar and North India, and *N.P.* 6 with tall and unbranched stems and capacity to mature early is suited for areas where a rabi crop can be raised after harvesting the fibre crop. In U.S.S.R. also, diversities in types and variations in vegetative and reproductive structures have been observed, and it has been found possible by selection alone to isolate types adapted for a wide range of soils and climates. Types corresponding to var. *viridis* (Type 2) and var. *vulgaris* (Type 8) are grown in Cuba (Howard & Howard, loc. cit.; *Agric. J. India*, 1915, **10,** 224; Shaw & Kashiram, *Agric. Live-Stk India*, 1934, **4,** 476; Haarer, 26–38; McCann, loc. cit.; Crane, *Econ. Bot.*, 1947, **1,** 334).

### Cultivation

*H. cannabinus* is essentially a tropical crop, thriving best in a humid climate with a temperature range of 60–80°F. during the growing season. It requires a rainfall of 20–25 in. distributed evenly over a period of 4–5 months, followed by a dry period. It is rather sensitive to frost and the limits of its cultivation lie between 45°N and 30°S latitudes. The plant is less exacting in its requirements than jute and is therefore preferred for cultivation as a jute substitute in parts of India and in sub-tropical countries (Haarer, 39; Crane, loc. cit.).

Besides temperature and rainfall, the length of day also influences the growth and maturation of the plant. Longer days favour rapid vegetative growth and flowering starts when the length of day begins to decrease. This photoperiodic influence is not a limiting factor in India and the cultivation period in most producing areas coincides with the long summer days; flowering commences towards the end of the monsoon period (October-November) when the length of day begins to decline. Outside the tropics, however, the growing season has to correspond with long days. Investigations in Russia have shown that based on the photoperiodic response, four groups can be distinguished, namely, those in which the durations of the vegetative period are 90–110 days; 110–120 days; 120–130 days; and 140–150 days (Haarer, 10, 36, 40; Crane, loc. cit.; McCann, loc. cit.).

Bimli jute thrives best in well-drained, sandy loam soil, neutral in reaction and containing considerable quantity of humus; it does not grow under water-logged conditions. The alluvial soils of N. Gujarat, medium black soils of the Deccan and the red loam

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**HIBISCUS CANNABINUS — FLOWERING AND FRUITING BRANCHES**

and laterite soils of S. India are well suited for cultivation. It is generally grown mixed with other crops, such as bajra, jowar, ragi, rice and cotton, and also as a border crop in sugarcane and cotton fields. The plant is cultivated mainly as a *kharif* crop, i.e. sown from May to July and harvested in October–November. In areas of low rainfall, it is grown with protected irrigation (Haarer, 43; Mollison, III, 228; Yegna Narayan Aiyer, 446–47: Kirby, *Bull. imp. Inst., Lond.*, 1947, **45,** 117; Mukerji, 233; Yegna Narayan Aiyer, *Indian J. agric. Sci.*, 1949 **19,** 439; Gammie & Patwardhan, *Bull. Dep. Agric. Bombay*, No. 30. 1928, 7).

The seeds are sown broadcast or by drilling in rows 8–12 in. apart, the distance between plants in the row being 2–3 in. The seed rate is 10–15 seers per acre when a pure crop is raised. In S. India where the crop is grown alternating with five rows of jowar or ragi, the rows are about 6 ft. apart. When broadcast, seeds are sown fairly thick and the plants thinned out later. Thick sowing favours straight-growth without much branching and this is helpful for fibre production. Wider spacing is beneficial for seed production (Haarer, 46–50; *Rep. Indian Jute Comm.*, 1953–54, 224).

Seeds for sowing are collected from ripe pods; if collected before full ripening, they are stored for 2–5 months for maturing. Under ordinary storage conditions, seeds retain their viability for about 8 months. Seeds germinate in 3–10 days, depending on soil moisture and temperature. Except for thinning in the earlier stages and one or two hoeings till the plants attain a height of about 1 ft., practically no further attention is given to the crop. Being mostly a mixed crop, the plant participates in the cultural treatments given to the main crop with which it is associated (Crane, loc. cit.: Haarer, 48: Yegna Narayan Aiyer, 447; Roberts & Kartar Singh, 327: Mukerji, 233).

*Diseases and Pests*—A large number of diseases caused by fungi are reported from various countries. The more serious diseases recorded in India are dry root rot caused by *Macrophomina phaseoli* (Maubl.) Ashby, leaf spot by *Cercospora hibisci* Tracy & Earle, leaf blight by *Phyllosticta hibisci* Peck and stem rot by *Diplodia hibiscina* Cke. & Ell. Recently a brown rot caused by *Volutella* sp. has been recorded on most types grown in India. In Russia, a large number of fungi belonging to the genera *Alternaria, Fusarium, Penicillium* and *Trichothecium* have been found on seeds; some like *Fusarium* affect seed tissues and consequently germination (Crane, loc. cit.: *Indian J. agric. Sci.*, 1950, **20,** 107; Ghosh & George, *Indian Phytopath.*, 1953, **6,** 106; McCann, loc. cit.).

Among the insect pests reported, particular mention may be made of *Agrilus acutus* which produces an elongated gall on the stem, and *Podagrica apicefulva.* Seeds in storage are affected by *Spermophagus tessellatus;* the pest can be controlled by treatment with γ-BHC (*Mem. Dep. Agric. Madras*, No. 36, 1954, 1057; *Rep. Jute agric. Res. Inst., Indian Jute Comm.*, 1951–52, 114; *Rep. Indian Jute Comm.*, 1948–49, 14: ibid., 1953–54, 234).

### Harvesting and Fibre Extraction

The crop is ready for harvesting 3–5 months after the sowing. For fibre purposes, the harvesting is done at the flowering stage before seed setting; if delayed, the fibre obtained is coarse with little lustre. The plants are cut close to the ground with a sickle or pulled out by the roots, tied into bundles of 30 to 40 stalks, left on the field for a few days to dry and then steeped in water for retting. Attempts have been made in America and Europe to develop mechanical appliances, similar to the hemp harvest binder, for harvesting the crop (Haarer, 51–54: Crane, loc cit.).

The method of retting bimli is the same as that adopted for jute or sunn hemp. The leafy tops are cut off and the bundles steeped vertically in water for 2–3 days to soak the thick basal parts. They are then steeped in a horizontal position, after weighting with logs, stones, clods of earth or grass. The period of retting varies from 6 to 10 days depending upon the maturity of the crop at the time of harvesting, the temperature of water and the types of micro-organisms present. The progress of retting requires watching; under-retting does not facilitate the easy removal of fibre and the fibre obtained is harsh and brittle: over-retting weakens the strength of the fibre. Retted bundles are removed and the bark peeled off from the root upwards. The strips are gently beaten with a mallet or stick and rinsed in water to separate the fibre from adhering tissue. The clean fibre is washed, dried in the sun and made into bundles or hanks for marketing (Wlth India—Raw Materials, II, 330, 337; Haarer, 51–54, 56–57; *Jute Bull.*, 1951–52, **14,** 288).

Mechanical decortication (scutching) with or without retting has been tried in S. Africa and western countries. Scutched fibre is harsher, weaker and inferior in spinning quality in comparison with retted fibre (Haarer, 69–77; Hof, *Melliand Textilber.*, 1952,

**32,** 741 ; Staub, *World Crops*, 1953, **5,** 51 ; *Jute Bull.*, 1951–52, **14,** 288).

*Yield*—The yield of dry fibre ranges from 200 to 1,200 lb. per acre, according as the crop is grown mixed or pure. Yields as high as 2,000–2,700 lb. or more per acre have been reported from pure crops in other countries ; Watt has recorded a yield of 6,400 lb. of clean fibre per acre, on the basis of 1 lb. of fibre from 100 stalks taken at random ; the average fibre outturn works out to 16–17% of the weight of dry stalks (Yegna Narayan Aiyer, 448 ; Roberts & Kartar Singh, 454 ; Mollison, III, 228 ; Crane, loc. cit. ; Bally, *Ciba Rev.*, No. 108, 1955, 3902 ; Kirby, loc. cit. ; *Rep. Jute agric. Res. Inst., Indian Jute Comm.*, 1953–54, 91).

*Seed production*—Plants grown for fibre give a low seed yield. They are tall and seeds are difficult to collect. For seed purposes, late planting in July–August with wider spacing is advocated so that a crop of stunted growth with profuse branches is raised. The seeds start ripening from the lowest capsule upwards in succession and harvesting is done when the capsules in the middle tier become mature. The seeds are threshed out after drying by beating and cleaned by winnowing. The average yield of seed is 700–800 lb. per acre ; yields up to 1 ton per acre have been recorded (Crane, loc. cit. ; Haarer, 54–56, 49).

*Fibre characteristics*—Bimli jute fibre is extracted from the inner part of the cortex, outside the cambium layer. The fibre strands range in length from 5 to 10 ft. and are composed of ultimate fibres 1.5–6.0 mm. in length and 12–33$\mu$ in diameter. The ultimate fibres are cylindrical in shape with thickened walls and blunt or pointed ends, polygonal and rounded in cross section with small or large lumen. Two types of fibres, primary and secondary, are reported to be present in the bark. The primary fibres arising from the terminal meristem are more glossy and flexible than the secondary fibres which arise from cambial activity. The ratio of primary to secondary fibres varies according to the plant height and thickness. The barks of early maturing types contain a larger percentage of primary fibres than those of late maturing ones (Haarer, 13–15 ; Matthews, 330).

The fibre is comparable to jute in lustre, but is somewhat coarser, harsher and more brittle and inflexible ; it is more resistant to rot. It can be spun alone or in admixture with jute, on machinery employed for jute spinning without major modifications. It can be spun to 10 lb. yarn with an average quality ratio (QR) of 80 ; well-grown, early harvested and properly retted fibre has a QR of at least 90 (the QR figures for 10 lb. white jute yarns vary from 80 to 105 ; those for tossa yarn, from 90 to 115). Spinning tests have shown that bimli jute of QR 80 in 10 lb. yarn can be mixed with an equal weight of medium quality jute (QR 90 in 10 lb. yarn) for average hessian weft yarns ; superior grades may be used in higher proportions. Bimli fibre cannot be spun to such fine yarns as 8's, for which first quality jute is used. The strength and other physical properties of bimli, jute and roselle (from *H. sabdariffa* var. *altissima*) fibres are given in Table 1 (Haarer, 18–20 ; *Jute Bull.*, 1949–50, **12,** 96, 454 ; ibid., 1953–54, **16,** 425 ; Ray, ibid., 1952–53, **15,** 79).

TABLE 1—PHYSICAL CHARACTERISTICS OF BIMLI, ROSELLE & JUTE FIBRES*
(basis: 15 in. fibre bundles weighing 5 g.)

| | Bimli | Roselle | Jute: High grade | Jute: Low grade |
|---|---|---|---|---|
| Fineness (1,000 ft./lb.) | 270 | 287 | 880 | 490 |
| Breaking strength (lb.) | | | | |
| Dry | 44 | 46 | 53 | 43 |
| Wet | 40 | 47 | 44 | 36 |
| Breaking strength after weathering (lb.)† | 42 | 33 | 41 | 29 |
| Flexural endurance (cycles) | | | | |
| At 50% original strength | 200 | 400 | 420 | 560 |
| At strength of 20 lb. | 150 | 450 | 710 | 620 |
| Elongation at rupture (%) | | | | |
| Dry | 1.7 | 1.7 | 1.7 | 1.3 |
| Wet | 2.1 | 1.8 | 1.5 | 1.3 |

* Matthews, 331. † after 100 hr. exposure in a twin-arc weatherometer.

*Chemical characteristics*—The cellulose content of bimli fibre ranges from 68.8 to 79.9%. Examination of numerous fibre samples (moisture content, 8.2–12.5%) from different parts of the world gave the following range of values (moisture-free basis): ash, 0.4–3.2 ; $\alpha$-hydrolysis loss, 6.1–17.9 ; $\beta$-hydrolysis loss, 9.3–22.1 ; acid purification loss, 0.6–6.7 ; loss on washing with water, 0.4–7.6 ; and cellulose, 68.8–79.9% ;

TABLE 2—ANALYSIS OF BIMLI, ROSELLE AND JUTE FIBRES*
(% on moisture free basis)

| | Indian commercial bimli | Roselle† | Jute: Low grade | Jute: Extra fine grade |
|---|---|---|---|---|
| Ash | 1.3 | 1.1 | 0.9 | 0.7 |
| α-Hydrolysis loss | 11.8 | 12.3 | 13.2 | 9.1 |
| β-Hydrolysis loss | 15.1 | 17.8 | 16.1 | 13.1 |
| Acid purification loss | 1.0 | 1.4 | 2.6 | 2.0 |
| Cellulose | 75.4 | 73.9 | 71.4 | 77.7 |

* Haarer, 17, 88.

comparative values for Indian bimli, roselle and jute are given in Table 2. The celluloses present are (oven-dry basis): holocellulose, 88.2 ; α-cellulose, 61.6 ; and hemicellulose, 14.2%. As in the case of jute and roselle, the alcohol-insoluble hemicellulose is composed predominantly of pentoses (xylose and uronic acid). The fibre contains (oven-dry basis): lignin, 5.95 ; total furfuraldehyde, 11.30 ; cell furfuraldehyde, 8.90 ; furfuraldehyde from polyuronides, 2.4 ; and xylan in cellulose, 13.8%. Other constituents present in the fibre are proteins, organic bases, carbohydrates, chiefly polysaccharides (starch and dextrins, 7–9%), pectins, tannins, phosphatides, wax and resinous substances. The ash contains calcium, magnesium, sodium and potassium (Haarer, 16 ; Mazumdar, *J. sci. industr. Res.*, 1955, **14B,** 542 ; Norman, *Biochem. J.*, 1937, **31,** 1575 ; *Chem. Abstr.*, 1930, **24,** 6023).

Bimli fibre, though coarser than jute, contains less lignin (bimli, 6.3–9.6% ; jute, 10.5–14.3%). Its coarseness is attributed to the uneven spread of the encrusting lignin : the higher xylan content (13.8% as compared to 10.2% in jute) may also account for the coarseness. In its reaction to iodine and sulphuric acid, bimli fibre resembles sunn hemp (from *Crotalaria juncea*). The median layer of lignin surrounding the cell wall gives a much darker colour reaction than the inner layer. The copper number of bimli cellulose is 0.75 (Norman, loc. cit. ; Biswas, *Curr. Sci.*, 1935, **3,** 571 ; Das *et al.*, *Sci. & Cult.*, 1950–51, **16,** 117 ; *J. sci. industr. Res.*, 1955, **14B,** 407 ; Matthews, 331 ; Ramamurti, *Proc. Rajasthan Acad. Sci.*, 1951, **2,** 22).

Jute has a higher fibre quality index (≮47.6) than bimli fibre (≯40.7). The proportion of acetyl groups present in the two fibres is also significantly different : the upper limit for jute fibre is 92 milli-equivalents of acetic acid /100 g. of oven-dry fibre (86.4–92.1 for *Corchorus capsularis* and 71.6–78.5 for *C. olitorius*), while the lower limit for *Hibiscus* fibre is 98 milli-equivalents of acetic acid (98.1–124.3). The two fibres may be distinguished by the examination of the ashes obtained by incineration ; clusters of crystals are present in abundance in the ash of *Hibiscus* fibre ; such crystals are less frequent in the ash of jute ; further, the crystals in the latter occur in chains in the region of nodes ; the nature of the crystals, however, has not been fully established (Das *et al.*, *J. sci. industr. Res.*, 1955, **14B,** 407 ; Sontar & Dryden, *J. Text. Inst.*, 1955, **46,** T521 ; Jarman & Kirby, *Colon. Pl. Anim. Prod.*, 1955, **5,** 281 ; Cornelius, ibid., 1955, **5,** 286).

Bimli fibre is suitable for the manufacture of paper pulp. Pulping tests show that it can be readily cooked with 15% caustic soda solution (yield of pulp, 83.4%) ; the pulp is easy to bleach. It may be used in blends with pulps from short-fibred hardwoods or agricultural residues for imparting high tearing strength to specialty papers. Bimli waste, containing woody material, could likewise be cooked with caustic soda (15%) to yield strong pulp (Lathrop & Nelson, *Indian Pulp Pap.*, 1954–55, **9,** 27).

*Uses*—Bimli fibre is widely used for rope and cordage. Considerable quantities are used in making fishing nets and strings for tying rafters. It is also used for coarse canvas, sacks and gunny bags, floor matting, rug backing, chair backing, etc. Fibre of poor quality and cuttings is employed in paper manufacture (Crane, loc. cit. ; Haarer, 21, 25 ; Sircar, *Misc. Bull. Indian Coun. agric. Res.*, No. 66, 1948, 30 ; *Possibilities of the Development of Fibre Industry in the Province of Bombay*, 11 ; Dalziel, 127).

The stalks left after fibre extraction can be used as fuel. Dried stalks are reported to be useful for match splinters (Duthie & Fuller, I, 86).

*Seeds*—Bimli seeds (c. 5 mm. × 3 mm.) are tetrahedral in form with a strongly adherent coat difficult to separate from the kernel. Analysis of whole seeds gave the following values: moisture, 9.64 ; mineral matter, 6.40 ; fatty oil, 20.37 ; nitrogenous matter, 21.44 ; saccharifiable matter, 15.66 ; crude fibre, 12.90 ; and other matter, 13.94% (Lewy, *J. Amer. Oil Chem. Soc.*, 1947, **24,** 3).

Whole seeds, after milling, cooking and hydraulic pressing yield *c.* 13% fatty oil ; better yields are obtained by solvent extraction. Cold pressed oil is clear yellow in colour and almost odourless. Table 3

TABLE 3—CHARACTERISTICS OF HIBISCUS SEED OILS*

| | *H. cannabinus* | *H. esculentus* | *H. sabdariffa* | *H. manihot* |
|---|---|---|---|---|
| Fat content (%) | 18–20 | 16–22 | 17 | 13.4 |
| Sp. gr. | 0.917–0.926 (15°/15°) | 0.916–0.919 (25°/25°) | 0.923 (15°/15°) | 0.9194 (20.5°/20.5°) |
| $n_D^{25°}$ | .. | 1.468–1.473 | 1.4715 (at 20°) | 1.4695 (at 23°) |
| $n_D^{40°}$ | 1.465–1.466 | 1.462–1.467 | .. | .. |
| Acid val. | 0.5–5.0 | 0.2–10.0 | 4.4 | 6.0 |
| Sap. val. | 189–195 | 192–199 | 193 | 197 |
| Iod. val. | 93–105 | 90–100 | 107.3 | 103 |
| Hydroxyl val. | .. | 4.9 | .. | .. |
| R.M. val. | .. | 0.3–0.6 | .. | .. |
| Polenske val. | .. | 0.3–0.8 | .. | .. |
| Unsapon. matter (%) | 0.4–3.4 | 0.7–1.4 | 1.1 | 0.92 |

* Eckey, 661–62.

FIG. 49. HIBISCUS CANNABINUS—SEEDS

gives the characteristics of oils from the seeds of bimli and other *Hibiscus* spp. The component fatty acids of bimli seed oil (iod. val., 99.7) are: oleic, 45.3; linoleic, 23.4; palmitic, 14.0; and stearic, 6.0%. The oil is used as a lubricant and for lighting. It is suitable for soaps, especially hard soap, and for the manufacture of linoleum, paints and varnishes. Refined oil is edible and may be used as salad oil and for cooking (Haarer, 23; Lewy, loc. cit.; Burkill, I, 1165; Eckey, 662).

The press cake, left after the extraction of oil, is grey in colour and resembles linseed and rapeseed cakes in composition. Analysis of a sample gave the following values (dry wt.): crude protein, 33.0; oil, 6.0; crude fibre, 17.4; ash, 6.0; and N-free extr. (by difference), 37.6%. An albumin and two globulins have been separated from the meal. The following amino acids have been identified in the acid hydrolysates of the proteins: *albumin* (N, 15.38%): histidine, 2.57; arginine, 6.23; tyrosine, 1.80; lysine, 3.05; *globulin*-1 (N, 18.41%): histidine, 3.68; arginine, 13.60; tyrosine, 2.13; lysine, 2.63; *globulin*-2: histidine, 3.24; arginine, 12.16; tyrosine, 2.04; lysine, 1.95%. The cake may be used as a fertilizer; it contains: nitrogen, 5.25; phosphoric acid ($P_2O_5$), 0.95; and potash ($K_2O$), 3.74% (Lewy, loc. cit.; Adriaens, 193; *Chem. Abstr.*, 1931, **25**, 3376).

The colouring matter of the yellow flowers consists mostly of the glucoside cannabiscitrin [$C_{21}H_{20}O_{13}$: yellow crystals; m.p., 245° (decomp.)] along with a small amount of the aglucone, cannabiscetin (3:5:7:3′:4′:5′-hexahydroxy flavone, $C_{15}H_{10}O_8$; m.p., 154–55°), a flavonol identical with myricetin. Cannabiscitrin on hydrolysis with dilute sulphuric acid yields glucose and cannabiscetin. The glucoside carries the glucose residue in position 3′ of the phenyl side chain (Neelakantam *et al.*, *Proc. Indian Acad. Sci.*, 1941, **14A**, 105; Seshadri & Venkateswarlu, ibid., 1946, **23A**, 296; Ahluwalia *et al.*, *J. sci. industr. Res.*, 1953, **12B**, 131).

Tender leaves of *H. cannabinus* are used as pot-herb. Leaves, tops and tender branches are used as cattle fodder, especially for cows and buffaloes in milk. The leaves are considered purgative and aperient. The juice of the flowers mixed with sugar and black pepper is a remedy for biliousness. Seeds

are used as feed for cattle and poultry; they are sometimes used for human consumption after roasting and crushing. They are stomachic, appetising, aphrodisiac and fattening; they are also employed externally as poultice for pains and bruises (Yegna Narayan Aiyer, 446; Kirt. & Basu, I, 328; Haarer, 22).

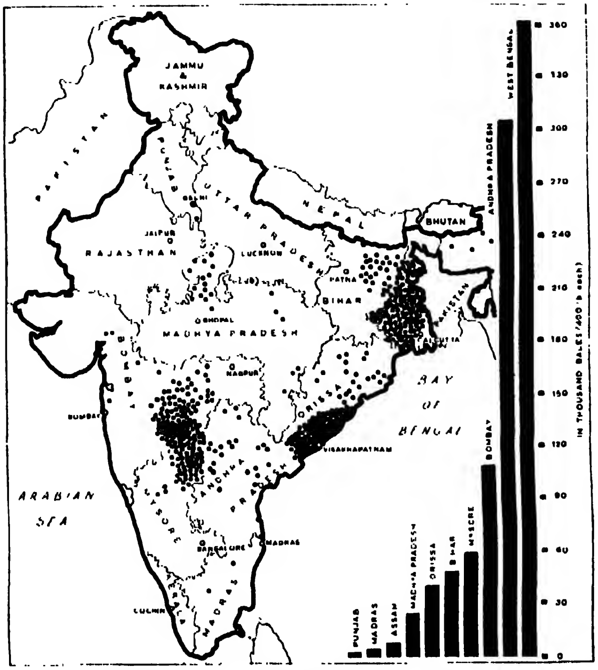



FIG. 50. ACREAGE & PRODUCTION OF MESTA
(av. 1953/54 - 1955/56; • - 1,000 acres)

The trade names Mesta and Kenaf are common to both *H. cannabinus* and *H. sabdariffa* fibres. This has resulted in considerable confusion in literature on the distribution of the two species. At one time the area cultivated for mesta fibre was almost entirely under *H. cannabinus*, but of late, *H. sabdariffa* var. *altissima* has been introduced in areas where jute cannot be grown and considerable areas have been brought under this crop. Statistical data relating to acreage and production of mesta include both crops. The two species can be distinguished from each other particularly by the adnate nature of the bracteoles in the flowers and fruits of *H. sabdariffa*. Table 4 gives the statewise acreage and production of mesta in India.

*Marketing*—The cultivators usually sell their produce to local merchants who, in turn, sell it to jute mills or shippers in the main marketing centres. For export, the fibres are pressed in bales of 330-400 lb.

The fibre is broadly classed in the trade as Mesta and Bimli; the former is usually obtained from the jute growing areas of Bengal, Assam, Bihar, U.P. and Orissa, and the latter from Andhra and Madras. The fibre is graded on the basis of colour, lustre and percentage of stalks, dirt, etc. The grades recognised are: F.A.Q. (fair average quality); A.Q. (average quality); and rejection. Suggestions have been made to grade the fibre into Tops, Middles, Bottoms and Cross-bottoms, and also to base grading on quality characteristics as follows: straight or tangled, colour, extent of cuttings, percentage of stick and foreign

TABLE 4—ACREAGE & PRODUCTION OF MESTA FIBRE*

| | Area (thousand acres) | | | | | Production (thousand bales of 400 lb. each) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1952-53 | 1953-54 | 1954-55 | 1955-56 | 1956-57 | 1952-53 | 1953-54 | 1954-55 | 1955-56 | 1956-57 |
| Andhra Pradesh | 237 | 138 | 179 | 123 | 124 | 394 | 292 | 326 | 270 | 261 |
| Assam | 3 | 3 | 3 | 5 | 5 | 8 | 9 | 4 | 9 | 11 |
| Bihar | 26 | 17 | 31 | 24** | 54 | 26 | 16 | 40 | 35** | 105** |
| Bombay | 85 | 159 | 90 | 114 | 150 | 83 | 146 | 98 | 109 | 165 |
| Madhya Pradesh | 46 | 25 | 22 | 25 | 24 | 26 | 21 | 25 | 21 | 19 |
| Madras | 2 | 4 | 1 | 1 | 1 | 3 | 7 | 2 | 2 | 2 |
| Mysore | 41 | 87 | 39 | 63 | 57 | 39 | 87 | 49 | 54 | 55 |
| Orissa | 25 | 17 | 21 | 23 | 25 | 50 | 34 | 41 | 45 | 50 |
| Punjab | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| West Bengal | 18 | 12 | 141 | 193** | 297 | 51 | 36 | 431 | 612** | 804** |
| TOTAL | 484 | 463 | 528 | 572 | 738 | 682 | 650 | 1,018 | 1,159 | 1,474 |

* Data obtained from the Directorate of Econ. & Statist., Minist. Food & Agric. ** Data relate to set up of States prior to reorganization.

matter (Sircar, *Misc. Bull. Indian Coun. agric. Res.*, No. 66, 1948, 30 ; Kar, 106–107).

In the earlier days, bimli fibre obtained exclusively from *H. cannabinus* was being exported in small quantities under the name Deccan Hemp or Bimlipatam Jute, the main importing countries being U.K., France and Germany, where the fibre was used for mixing with jute (Sircar, *Misc. Bull. Indian Coun. agric. Res.*, No. 66, 1948, 30 ; *Handbook of Commercial Information for India*, 1937, 155).

Prior to 1949, production of mesta was small and most of it was exported to foreign countries. With the devaluation of the Indian rupee, the consumption of mesta by Indian mills received a stimulus, largely due to its cheapness as compared to jute (Table 5). The production of mesta increased from 7 lakh bales in 1952–53 to more than 14 lakh bales in 1956–57, the increase being particularly marked in West Bengal. Considerable apprehension has been felt that unlimited production of mesta and its utilization along with jute would adversely affect the quality of jute goods ; also if the cultivation of mesta is allowed to increase at the existing rate, jute production in West Bengal may receive a set-back. This matter has been recently examined by a committee appointed by the Government of India, which recommends, that though there are valid reasons for encouraging the production of mesta, the production should not be at the cost of jute, particularly white jute ; mesta should be encouraged, but not as a replacement of jute or paddy. The following centres have been recommended for mesta production: Bihar (Purnea, Baidyanath, Jhajha, Dalkela, Samastipur) ; U.P. (Bareilly, Bhajoi, Dekanal, Pilibhit, Rampur, Chandausi, Faizabad) ; Orissa (Sambalpur, Barghar, Kesinga) ; West Bengal (Malda, Asansol sub-division, Bishanpur sub-division) ; Andhra (Parvatipuram, Pathattam, Vizianagaram, Nellimarla, Pondura, Sigadam, Srikakulum Road, Tilaru, Sitanagaram) (*Rep. Jute Enquiry Comm.*, Minist. Food & Agric., India, 1957).

TABLE 5—AVERAGE WHOLESALE PRICE OF MESTA AT GARSAT & OF JUTE AT CALCUTTA
(price in Rs-as per md.)

| | | Jute | |
|---|---|---|---|
| | Mesta | Middle | Bottom |
| 1952–53 | 16–0 | 23–1 | 20–9 |
| 1953–54 | 20–3 | 27–13 | 24–4 |
| 1954–55 | 24–12 | 29–9 | 26–10 |
| 1955–56 | 25–11 | 25–14 | 22–12 |
| 1956–57 | 27–1 | 30–12 | 27–12 |

Being similar to jute in spinning characteristics, mesta is used on a fairly large scale in jute manufactures (sometimes to the extent of 60–80% in hessian and sackings). In 1955–56, the entire production of nearly 11 lakhs of bales of mesta was consumed by jute mills ; the consumption is expected to increase to about 20 lakhs bales by 1960–61.

**H. esculentus** Linn. = *Abelmoschus esculentus* (Linn.) Moench. LADY'S FINGER, OKRA, GUMBO

D.E.P., IV, 237 ; C.P., 631 ; Fl. Br. Ind., I, 343.

HINDI *Bhindi, bhindi tori, ramturai* ; BENG.—*Dheras* ; GUJ.—*Binda* ; MAR.—*Bhendi* ; TEL.—*Venda, bendi* ; TAM.—*Vendai* ; KAN.—*Bhende* ; MAL.—*Bendai, venda.*

An annual herb with a tall, erect stem, 3–7 ft. high, covered with hairs ; leaves cordate, palmately 3–5 lobed, coarsely toothed ; flowers large, yellow with a crimson centre ; pods 5–12 in. long, pyramidal-oblong (horn-like), green or creamy green in colour, with longitudinal ridges, smooth or hairy ; seeds many, rounded, striate, hairy.

The plant is considered to be African or Asian in origin and is valued for its edible pods. It is grown as a garden crop or homeyard plant throughout the tropical and subtropical parts of the world. It is found under cultivation throughout India up to an altitude of 4,000 ft. It is seldom cultivated as a field crop.

Numerous types, indigenous and imported, are under cultivation. They are distinguished by their growth habit, length of pods, colour of stem and pods, nature of pod surface and number of ridges (ribs) on pods. There are tall and dwarf forms with long or short pods maturing early or late ; the pods may bear five or eight ridges. Some of the best imported types are Clemson, Spineless, American Long Green and White Velvet ; they are mostly free from spiny hairs and bear pods with faint ribs. Several local strains with smooth pods are also known. A new type, *Pusa Makhmali*, isolated by the Indian Agricultural Research Institute bears green pods 6–8 in. long, straight, five-ribbed and smooth [Thompson, 573 ; Firminger, 164 ; Ambekar, *Bull. Dep. Agric. Bombay*, No. 146, 1927, 111 ; Venkataramani, *Madras agric. J.*, 1945, **33**, 221 ; Singh & Sikka, *Indian Fmg, N.S.*, 1954–55, **4**(11), 27 ; *Rep. Indian Coun. agric. Res.*, 1952–53, 42 ; Gollan, 185 ; Gopalaswamiengar, 534].

*Culture—H. esculentus* can be grown on any type of soil, but does best on well manured loam soils,

HIBISCUS ESCULENTUS — FLOWERING AND FRUITING BRANCHES

Two crops are usually raised in a year, one sown in the beginning of summer (February–March) and harvested in July–August; and the second sown with the onset of rains in June and harvested in October–December. For the summer crop, early maturing types with five-ribbed, smooth pods are preferred, while for the rainy season crop, late maturing types with eight-ribbed, smooth or hairy pods are grown. A number of types suitable for growing in both seasons are available; *Pusa Makhmali* is an outstanding example (Roberts & Kartar Singh, 374; Milne *et al.*, 111; Chandrasekharan & Ramakrishnan, *Madras agric. J.*, 1929, **17**, 7; Singh & Sikka, loc. cit.).

The land is ploughed 3–4 times and farmyard manure applied at the rate of 20–25 cart loads per acre. Seeds are sown broadcast or are dibbled in holes, 2 or 3 seeds per hole. They may be drilled also in shallow furrows, 9 in. apart, with a spacing of 3 in. between plants in the furrow. In some places, seedlings are raised in nurseries and transplanted in the garden. The seed rate ranges from 5–30 lb. per acre. To get a continuous supply of fruits, it is usual to sow the seeds in batches, in different beds, at intervals of 2–3 weeks during the sowing season. The plant responds well to proper interculture and weeding. In the case of the summer crop, it may be necessary to irrigate the plants once in 7 or 10 days (Gollan, 86; Milne *et al.*, 112; Choudhri, 76; Singh & Sikka, loc. cit.).

*Diseases and pests*—*H. esculentus* is subject to dry root rot [*Macrophomina phaseoli* (Maubl.) Ashby], leaf spot (*Cercospora hibisci* Tracy & Earle), anthracnose (*Colletotrichum hibisci* Poll.), mildew (*Erysiphe cichoracearum* DC.), seedling blight (*Phytophthora palmivora* Butler) and fruit rot (*Pythium indicum* Balakrishnan). The plant is also affected by yellow vein mosaic, a virus disease common throughout India. The characteristic symptoms of the disease are: clearing of veinlets followed by chlorosis of veins, vein swelling, slight downward curling of leaf margins and twisting of petioles, and general retardation of growth. The white-fly, *Bemisia tabaci* Gen., is the insect vector of the virus. The following control measures have been suggested: eradication of *H. tetraphyllus*, the wild host of the virus; observing a closed season of two months during summer between two successive crops; roguing diseased plants at the earliest stage of infection; spraying the crop once in 3 weeks with fish oil rosin soap; and keeping fields clean of weeds. A top dressing of Nicifos is reported to check the disease. Spraying of plants with Pyrocolloid (1 part in 800 parts of water) or Derriphyton (1% soln) destroys white flies and thus reduces the spread of the disease. Sprinkling of plants with wood ashes is also reported to reduce the spread of the disease [*Indian J. agric. Sci.*, 1950, **20**, 107; Balakrishnan, *Proc. Indian Acad. Sci.*, 1947 **26B**, 142; ibid., 1948, **27B**, 161; Capoor & Varma, *Indian J. agric. Sci.*, 1950, **20**, 217; *Indian Fmg, N.S.*, 1952–53, **2**(12), 14; Jha & Mishra, *Proc. Bihar Acad. agric. Sci.*, 1955, **4**, 129; Choudhri, 76].

Almost all the insect pests of cotton are known to attack *bhindi*. Cotton jassids suck the sap from the plants and crumple the leaves; spraying with 0.2% DDT (wettable powder) is employed as a control measure. Cotton bollworms bore through the growing shoots and young fruits; affected shoots and fruits are hand-picked and destroyed, and the land is kept in a fine mulch. Red mite attacks the leaves and sucks the sap; the pest is controlled by dusting with sulphur or with a mixture of sulphur and lime (1 : 5); treatment with 15–25% DDT emulsifiable concentrate is also effective (*Mem. Dep. Agric. Madras*, No. 36, 1954, 943; Singh & Sikka, loc. cit.; Manickavasagar, *Trop. Agriculturist*, 1955, **111**, 28).

*Yield*—The fruits of the summer crop are ready to be picked 40–50 days after sowing; fruiting in monsoon crops takes a little longer, 60–70 days from sowing. The fruiting period in summer extends over 2 months; the period is much longer in the rainy season crop and extends up to the winter season. The fruits become tough after gathering and should therefore be disposed off as soon as possible (Singh & Sikka, loc. cit.; Gollan, 86; Gopalaswamiengar, 554; Thompson, 572).

The average yield of green pods per acre is reported to be 4,000–5,000 lb.; higher yields are obtained under favourable conditions. *Pusa Makhmali* is reported to have given a yield of 16,400–20,500 lb. of pods per acre (Biswas *et al.*, *Indian Text. J.*, 1951–52, **62**, 297; Singh & Sikka, loc. cit.).

For seed purposes, a part of the garden may be set apart and pods allowed to develop to maturity or one or two pods may be left over in individual plants. The seeds collected from pods left over in picked plants are not considered to be particularly good for sowing purposes; further flowering and fruiting tend to diminish in plants which are not regularly picked for tender pods. For ensuring type purity, it is advisable to grow only one type in any one locality. The yield of seeds from individual plants varies from ½ to 1 oz.; a higher yield is obtained from the rainy

season crop than from the summer crop. The collection of seeds is difficult. All pods do not mature at the same time and mature pods tend to burst open and scatter the seeds. Recently, dwarf and semi-dwarf types have been isolated by selection in which the pods do not burst after ripening. A yield of 2,500 lb. per acre when grown on fertile alluvial land and 600–1,000 lb. per acre from less sandy soils has been reported. An average yield of 320–480 lb. of seed per acre is reported from *Pusa Makhmali* [Singh & Sikka, loc. cit.; Rao, *Madras agric. J.*, 1953, **40**, 437; Schoeffelmayer, *Chemurg. Dig.*, 1948, **7**(9), 17; Miller & Wilson, ibid., 1949, **8**(5), 22].

*Uses*—Tender pods are used as vegetable. They are eaten boiled or in the form of sliced and fried pieces. They are also used for thickening soups and gravies because of their high mucilage content. Sometimes, they are sliced and sun-dried for off-season use; dried slices are reported to be produced in Turkey on a large scale. Pods may also be canned and pickled (Chandrasekharan & Ramakrishnan, loc. cit.; Firminger, 164; Siddappa & Mustafa, *Misc. Bull. Indian Coun. agric. Res.*, No. 63, 1946, 19; Thompson, 574).

The pods are rich in pectin and mucilage. Analysis of fresh pods gave the following values: moisture, 88; protein, 2.2; fat (ether extr.), 0.2; mineral matter, 0.7; fibre, 1.2; carbohydrate, 7.7; calcium, 0.09; and phosphorus, 0.08%; iron, 1.5 mg./100 g. The mineral constituents present (fresh basis) are: magnesium, 38; potassium, 220; sodium, 1; and sulphur, 14 mg./100 g.; copper, manganese and iodine (0.7γ/100 g.) are reported to be present. *Bhindi* is a fair source of iron and calcium. The presence of a flavonoid compound has been reported (Wehmer, II, 757; *Hlth Bull.*, No. 23, 1951, 38; Sherman, 685; Remington & Shiver, *J. Ass. off. agric. Chem. Wash.*, 1930, **13**, 129; Iodine Content of Foods, 80; Basu & Ghosh, *Indian J. med. Res.*, 1943, **31**, 29, 37; *Biol. Abstr.*, 1953, **27**, 229).

Fresh pods (moisture, 89.8%) are reported to contain: vit. A, 740 i.u.; thiamine, 0.08 mg.; riboflavin, 0.07 mg.; ascorbic acid, 30 mg.; and niacin, 1.1 mg./100 g. Tender pods are richer in ascorbic acid than mature pods. Cooked pods contain: vitamin A, 740 i.u.; thiamine, 0.06 mg.; riboflavin, 0.06 mg.; ascorbic acid, 20 mg.; and niacin, 0.8 mg./100 g. Pressure cooking minimises the loss of ascorbic acid (Watt & Merrill, *Agric. Handb. U.S. Dep. Agric.*, No. 8, 1950, 35; Pal *et al.*, *Bot. Gaz.*, 1951–52, **113**, 455; Hollinger & Colvin, *Food Res.*, 1945, **9**, 255).

FIG. 51. HIBISCUS ESCULENTUS—PODS

*Mucilage*—Mucilaginous extracts of green stems are commonly employed in India for clarifying sugarcane juice in gur manufacture. A thick colourless extract is prepared by pounding the lower portions of the stem along with a portion of the root in water and straining through cloth. The extract is added to cane juice at the boiling stage. The albumins present in the extract coagulate and carry the suspended and colloidal impurities present in the cane juice to the surface as a scum. The gur obtained from clarified juice is hard and crystalline with a golden yellow colour (Roy, 25; Khanna & Chacravarti, *Indian J. agric. Sci.*, 1949, **19**, 137).

Analysis of the mucilaginous extract prepared by pounding 1 part of green stem with 20 parts of water gave the following values: crude protein, 79; true protein, 13; ash, 92; sol. silica, 16; $P_2O_5$, 2; $Al_2O_3 + Fe_2O_3$, 4; and CaO, 3 mg./100 cc.; MgO, traces (Khanna & Chacravarti, loc. cit.).

A mucilaginous preparation from the pod has found application as a plasma replacement or blood volume expander. Experimental animals (dogs)

bled to a state of shock, recovered completely when transfused with the preparation, and blood regeneration and recovery were speeded up when the preparation was supplemented with a small quantity of the animal's blood. The preparation caused no reaction. The mucilaginous material is prepared by grinding the pod, removing waxes and fats with ether and alcohol, suspending the purified material in water, filtering, and finally concentrating the filtrate. It may be obtained in powder form by precipitation or freezing and stored for use when required. The preparation contains *d*-galactose, *l*-rhamnose and *d*-galacturonic acid. Partial acid hydrolysis, followed by chromatographic separation, gives a crystalline galactobiose (4-*o*-*α*-d-galactopyranosyl-d-galactopyranose) and an aldobiouronic acid (2-*o*-d-galactopyranosyluronic acid-l-rhamnose [*Chemurg. Dig.*, 1951, **10**(3), 14 ; *Chem. Abstr.*, 1951, **45**, 9805 ; Whistler & Conrad, *J. Amer. chem. Soc.*, 1954, **76**, 3544 ; *J. agric. Fd Chem.*, 1954, **2**, 398].

The leaves and roots of the plant contain a mucilage similar to that present in the pods. The root mucilage is used in China as a sizing for paper. Leaf mucilage is used as a substitute for soap to remove oil. The leaves are eaten by cattle (Burkill, I, 1166 : Chandrasekharan & Ramakrishnan, loc. cit.).

The whole plant is aromatic emitting an odour resembling cloves. The leaves contain a volatile oil. Ammonia and amines are present in the plant in free as well as in combined forms. Iodine is also present and its concentration is greatest in those parts of the plant where the green colouring matter is also most concentrated. Leaves and stems are richer in iodine than the roots (*Chem. Abstr.*, 1942, **36**, 3824 ; 1936, **30**, 3110).

*Seeds* Ripe seeds are roasted and used as a substitute for coffee. They are also used in curry and chutney. The seed flour is reported to be used in Egypt as an addition to maize flour. Analysis of the seeds gave the following values: moisture, 9.89 ; protein, 19.38 ; lipids, 16.78 ; crude fibre, 21.02 ; total sugar, 4.03 ; ash, 4.74 ; potassium, 0.82 ; phosphorus, 0.79 ; and calcium, 0.21%. The seeds contain: pentosans, 14.27 ; starch, 8.92 ; and total pectin, 2.15% (Ambekar, *Bull. Dep. Agric. Bombay*, No. 146, 1927, 111 ; Elkatile, *Nature, Lond.*, 1947, **159**, 716 ; Hussain & Dollear, *J. Amer. Oil Chem. Soc.*, 1950, **27**, 295 ; *Chem. Abstr.*, 1940, **34**, 6838).

Ripe seeds contain (16–22%) of an edible oil. The extraction of the oil on a commercial scale presents certain difficulties. The seeds are small

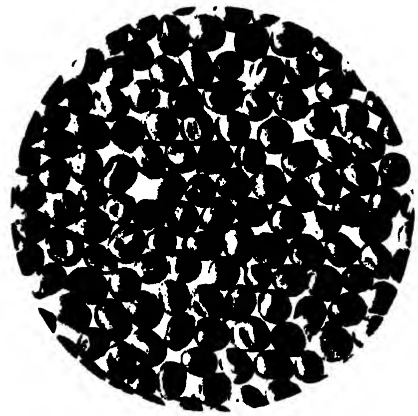


FIG. 52. HIBISCUS ESCULENTUS—SEEDS

(*c.* 4.5 mm. in diam.), almost spherical and the shell is hard and difficult to separate from the kernel. The yield of oil by pressing is low and a large part of it is retained in the cake. Solvent extraction gives better yield and the oil obtained is also of better quality. The oil obtained by solvent extraction of *bhindi* seeds is bright yellow in colour with a greenish tinge and fragrant odour. The greenish colour is ascribed to the presence of pheophytin-A in the shell. The oil can be refined, bleached and deodorised by the usual methods. The refined oil has good keeping quality. It can be used as a substitute for common edible oils, especially cottonseed oil. A shortening (iod. val., 70–77) with good keeping quality is obtained by hydrogenation ; it is similar to hydrogenated cottonseed oil of the same iodine value, but somewhat softer [Crossley & Hilditch, *J. Sci. Fd Agric.*, 1951, **2**, 251 ; Child & Nathanael, *Trop. Agriculturist*, 1948, **104**, 79 ; Eckey, 659–60 ; Edwards & Julian, *Chemurg. Dig.*, 1947, **6**(2), 29, 31 ; Hussain & Dollear, loc. cit.].

The characteristics of the oil are summarized in Table 3. Examination of an Indian sample showed: sp. gr.$^{30°}$, 0.9183 ; $n_D^{30°}$, 1.4704 ; viscosity, 0.1148 ; sap. val., 194.40 ; iod. val., 77.95 ; acid val., 12.14 ; acet. val., 5.6 ; Hehner val., 92.40 ; and unsapon. matter (contains sitosterol), 1.23%. The fatty acid composition of the oil is as follows: myristic, 0.70 ; palmitic, 21.20 ; stearic, 4.60 ; linoleic, 20.36 ; and oleic, 45.54% ; and 9-hexadecenoic acid, an oxygenated fatty acid identified as 12,13-epoxyoleic acid. γ-Tocopherol (0.043%) and α-tocopherol (0.031%) are present. The component glycerides of the oil (sample from Sudan ; iod. val., 94) are: disaturated-oleins, 14 ; disaturated-linoleins, 9 ; saturated-oleo-linoleins, 42 ; saturated-dilinoleins, 10 ; dioleo-linoleins, 2 ; oleo-dili-

noleins, 22 ; and trilinolein, 1% (mol.) [Singh & Dutt, *Indian Soap J.*, 1947–48, **13,** 99 : Chisholm & Hopkins, *Canad. J. Chem.*, 1957, **35,** 358 : Crossley & Hilditch, loc. cit. : Fisher, *Industr. Engng Chem.* (*Anal.*), 1945, **27,** 224].

The seed cake is rich in proteins and is suitable for use as animal feed, though the fibre content is undesirably high. Analysis of the cake gave the following values: *solvent-extd meal :* moisture, 9.10–9.40 ; protein, 23.87–31.88 ; crude fibre, 17.77–24.24 ; and lipids, 1.30–1.89% ; *pressed meal :* moisture, 10.49 ; protein, 22.56 ; crude fibre, 28.21 : lipids, 5.5 ; and ash, 5.45%. The meal contains thiamine (5γ/g.), an albumin and two globulins. The following amino acids have been identified in the acid hydrolysates of the proteins: *albumin* (N, 15.10%): histidine, 2.66 ; arginine, 6.53 : tyrosine, 1.37 ; and lysine, 2.92 ; *globulin-1 :* histidine, 3.08 ; arginine, 8.14 ; tyrosine, 3.49 ; and lysine, 2.54 : *globulin-2* (N, 17.95%): histidine, 3.68 ; arginine, 12.38 ; tyrosine, 3.68 ; and lysine, 2.85%. The meal prepared from decorticated seeds contains as high as 40–50% protein and has been recommended for use in plastics (*Colon. Pl. Anim. Prod.*, 1950., **1,** 71 ; Hussain & Dollear, loc. cit. ; *Chem. Abstr.*, 1931, **25,** 3376).

By sieving (50-mesh) the powdered cake, a fine meal (34%) free from seed coats and containing 3.5% crude fibre is obtained ; the residue consists mostly of seed coats (Child & Nathanael, loc. cit.).

The hulls may be used as a feedstuff. They contain: moisture, 12.33 ; crude protein, 12.25 ; fat, 6.7 ; N-free extr., 29.16 ; crude fibre, 35.73 ; ash, 3.83 ; CaO, 0.27 ; and $P_2O_5$, 0.76% (Edwards & Julian, loc. cit.).

The flowers contain two flavonol pigments, namely, gossypetin (3,5,7,8,3′,4′-hexahydroxy flavone, $C_{15}H_{10}O_8$ : m.p., 310–14°) and quercetin (3,5,7,3′,4′-pentahydroxy flavone, $C_{15}H_{10}O_7$ : m.p., 314°) in the form of their glucosides. The isolation of the glucosides is rendered difficult due to the presence of mucilage and resins in flowers, but the aglucone mixture can be isolated in a practically pure state (crude yield, gossypetin being the major component (Seshadri & Viswanadham, *Curr. Sci.*, 1947, **16,** 343 ; Pankajamani & Seshadri, *Proc. Indian Acad. Sci.*, 1953, **37A,** 718).

In West Africa, the flowers are eaten in soup. The tender leaves are sometimes boiled and eaten as spinach. Immature capsules are emollient, demulcent and diuretic, and are employed in the form of a decoction in catarrhal affections, ardor urinae, dysuria and gonorrhoea. Leaves are employed externally as emollient poultice. In Malaya, an infusion of the roots is used in syphilis. An infusion of roasted seeds has sudorific properties. The seeds are stimulant, cordial and antispasmodic (Dalziel, 128 ; Irvine, 248 ; Kirt. & Basu, I, 332–33 ; U.S.D., 1947, 1479 ; Quisumbing, 570).

*Fibre*—The stalks of *H. esculentus,* like those of other *Hibiscus* species yield a fibre which has not been commercially exploited. After fruiting, the stalks are generally allowed to go waste or used as fuel. If, however, they are collected green and subjected to retting without drying, a useful fibre can be extracted. The presence of mucilage in the stem facilitates fibre separation. The extracted fibre requires thorough washing to remove the mucilage ; otherwise, the fibre obtained is stiff and brittle. An average yield of 2.7 md. of fibre per acre has been reported (Biswas *et al.*, *Indian Text. J.*, 1951–52, **62,** 297).

The fibre of *H. esculentus* is white, light cream or yellow in colour, silky, strong and pliant, but somewhat coarse and stiff. The fibre has a breaking strain of 79 lb. when dry and 95 lb. when wet. It can be spun into yarn and used for rope, twine and sacking. The fibre can be spun on jute mill machinery and 10 lb. yarn can be used with 50% jute admixture for sacking warp or hessian weft. It can be used in 85% admixture with 15% of jute in sacking cloth. The fibre is also suitable for the manufacture of paper and cardboard. In West Africa, the fibre is used for fishing lines (Biswas *et al.*, loc. cit. ; Burkill, I, 1166 ; Dalziel, 129).

**H. ficulneus** Linn. – *Abelmoschus ficulneus* Wight & Arn.

D.E.P., IV, 240 ; C.P., 629 ; Fl. Br. Ind., I, 340.

Hindi—*Ran bhendi ;* Beng. *Ban-dheras, jangli bhindi ;* Tel. - *Nelabenda, parupubenda ;* Tam.—*Kattuvendai.*

Punjab—*Deola, dula, kapasiya.*

A much-branched, prickly annual, 6–14 ft. high, found from Punjab to Bengal and southward to Deccan and S. India. Leaves rounded, cordate at the base, upper leaves palmately 3-5 lobed ; flowers small, white with pink centre ; capsules 1¼–1½ in. long, tomentose, ovoid, covered with viscid hairs when green ; seeds globose, sulcate, slightly pilose.

*H. ficulneus* is a very variable species and includes types differing in their growth habit and flowering and fruiting times. The types collected from Punjab and Madhya Bharat are early ripening and tall with

erect or semi-erect lower branches; those from Madras and Madhya Pradesh are late ripening and dwarfish with spreading lower branches (Pal *et al.*, *Bot. Gaz.*, 1951–52, **113**, 455).

The plant can be raised from seeds sown in seed beds at the beginning of rains or earlier. Seedlings when *c.* 6 in. high are transplanted in rows 9 in. apart. The plant flowers in October-November and fruiting takes place in December-January.

The plant yields (2.87% of the wt. of green stem) a glossy, white fibre useful for twine and light cordage. The fibre is reported to be superior to that of *H. cannabinus*. It has a breaking strain of 104 lb. when dry and 115 lb. when wet.

The mucilaginous extract of the green stem is an efficient clarifier for sugarcane juice and it is employed for this purpose in gur manufacture. The extract is prepared in the same way as that of *H. esculentus* (q.v.) and *c.* 3.75 lb. of the plant material is sufficient to clarify 100 md. (3.7 tons) of cane juice. The extract contains (mg./100 cc.): crude protein, 316; true protein, 61; ash, 120; soluble $SiO_2$, 12; $P_2O_5$, 3; $Al_2O_3+Fe_2O_3$, 8; CaO, 2; and MgO, traces [Roy, 25–26; Khanna & Chacravarti, *Indian J. agric. Sci.*, 1949, **19**, 137; Wilcox, *Sugar*, 1952, **47**(8), 31; *Farm News Release, Indian Coun. agric. Res.*, No. 102].

The fruits are richer in vitamin C (38 mg./100 g.) than the fruits of *H. esculentus*. The seeds are aromatic and are used in the same way as those of *H. abelmoschus* for flavouring sweetmeats. In Arabia, they are employed for perfuming coffee. Farnesol and ambrettolide are reported to be the odorous constituents of the volatile oil from seeds [Pal *et al.*, loc. cit.; Krishna & Badhwar *J. sci. industr. Res.*, 1947, **6**(5), suppl., 64].

**H. furcatus** Roxb.

D.E.P., IV, 241; Fl. Br. Ind., I, 335; Talbot, I, Fig. 71.

TEL.—*Adavi gogu, konda gogu, danasoni gogu*; MAL.—*Naranampupuli, paccapuli*; KAN.—*Huligowri, gumchi*; ORIYA—*Piri-pirika.*

ASSAM (LAKHER)—*Kiasi.*

An erect or trailing, suffruticose, prickly herb, 2–5 ft. high, found as an undergrowth in the forests of Assam (Lushai hills), Chota Nagpur, Orissa, Andhra and Mysore: it occurs in the ghat forests from Konkan southwards to Kerala, up to an elevation of 3,000 ft. Leaves entire in early stages, 3–7 lobed in later stages, pubescent beneath; flowers large, yellow with purple centre; capsules ½ in. long, ovoid, pointed, enclosed in calyx; seeds striated, somewhat triangular.

The plant flowers in September-November and fruiting takes place in November-January. It is reported to be highly resistant to drought, remaining green even under prolonged dry periods (Reddy & Janki Devi, *Andhra agric. J.*, 1954, **1**, 309; Reddy, ibid., 1954, **1**, 366).

The leaves are acidic and are eaten after cooking. They are coarser and thicker than *H. cannabinus* leaves, and the presence of hairs and prickles prevents their wider use. They are said to improve digestion when eaten and are considered anthelmintic. The juice of leaves mixed with honey is applied in eye diseases. An infusion of the roots in water is used as a cooling drink in hot weather. A decoction of the root bark is given as a remedy for poisons and swellings, and for cleansing kidneys (Reddy & Janki Devi, loc. cit.; Rama Rao, 41; Kirt. & Basu, I, 327).

The stem yields a strong fibre suitable for cordage and rope, but the presence of prickles on the stem renders its extraction troublesome. The fibre has a breaking strain of 89 lb. when dry and 92 lb. when wet (Naidu, 124).

**H. macrophyllus** Roxb.

D.E.P., IV, 241; Fl. Br. Ind., I, 337.

BENG.—*Kashia udal, kashia palla.*

KHASI—*Tyllen-dkhar*; GARO—*Mao-marli*; MIKIR—*Pharna*; LUSHAI—*Baiza, vaiza.*

A small or medium-sized, deciduous tree or large shrub, covered more or less with brown, long tufted hairs, distributed in north-eastern India, Burma and Malaysia. Bark ¼ in. thick, light brown, smooth; leaves large, 5–14 in. wide, orbicular, deeply cordate, hairy on both sides; flowers 4 inches in diam., in axillary and terminal cymes, pale yellow fading to pinkish brown, with deep purple centre; capsules 1–5 in. long, yellow, oblong, pointed, bristly; seeds bearded with long silky tawny hairs. The plant comes to flower in March-April and bears fruits in May-June (Fl. Assam, I, 142; Bor, 165; Corner, I, 441).

The tree is found in open scrubs and abandoned jhums in Assam, Khasi, Jaintia, Aka and Lushai hills. It is reported to attain a height of 60–80 ft. and a girth of 5–6 ft. with a clean bole. Its heartwood is light (wt., 37 lb./cu.ft.), purplish brown, even-grained, soft but durable. It is useful for house posts. In Garo hills, the wood is used for rafters, posts and sill plates (Gamble, 87; Rodger, 48; Burkill, I, 1166; Fl. Assam, I, 143).

The inner layers of the bark yield a strong, rough fibre (length of ultimate fibre, 1.8–4.5 mm.), useful for coarse rope and cordage. The fibre is considered suitable for making paper of good quality. Analysis of two samples of the bark gave the following values (moisture-free basis): ash, 4.60, 4.23; water purification loss, 8.54, 5.27; acid purification loss, 7.03, 5.92; $\alpha$-hydrolysis loss, 15.94, 10.72; $\beta$-hydrolysis loss, 30.01, 21.20; and cellulose content, 54.20, 71.0% (Bishop, *Malay. agric. J.*, 1925, **13,** 382; Rodger, 48).

**H. manihot** Linn. = *Abelmoschus manihot* (Linn.) Medic. syn. *H. tetraphyllus* Roxb., *H. pungens* Roxb.

D.E.P., IV, 246; Fl. Br. Ind., I, 341; Talbot, I, Fig. 74.

MAR.—*Jangali bhendi*; GUJ.—*Kantalo bhendo*.

BOMBAY—*Ran bhendi*; ASSAM—*Usipak*.

A tall, erect, stout, glabrous or somewhat hairy herb or undershrub, 3–9 ft. high; leaves 5–6 in. × 6–7 in., deeply palmately lobed; flowers large, 5 inches in diam., yellow with a purple centre; capsules oblong, pointed, hispid, containing 5 seeds; seeds round or kidney-shaped, black and striated.

*H. manihot* is widely distributed in the tropics. Based on variations in foliage and pubescence, three varieties have been distinguished, namely, var. *genuinus*, var. *tetraphyllus* and var. *pungens*. It is considered to be a native of China and Japan and is reported to have been introduced into India from China, but its wide distribution, as recorded under the synonyms *H. tetraphyllus* and *H. pungens*, suggests that it occurs wild in this country. Under the name *H. pungens*, it has been recorded as growing throughout the tropical Himalayas from Kumaon to Sikkim up to an altitude of 3,000 ft. and in Bihar, Assam and Khasi hills. Under the name *H. tetraphyllus* it is recorded from Saurashtra, Rajasthan, Gujarat and Konkan southwards to Kerala. The types collected from Bengal and Baroda are comparatively late maturing with ascending lower branches; those from U.P. and Madhya Pradesh are early maturing with spreading lower branches (Duthie, I, 92; Prain, I, 266; Fl. Madras, 97; Fl. Assam, I, 144; Haines, I, 66; Mooney, 27; Santapau, 17; *Rec. bot. Surv. India*, 1953, **16,** 22; Pal *et al.*, *Bot. Gaz.*, 1951–52, **113,** 455).

The mucilage extracted from the root of *H. manihot* is widely used in sizing paper in China and Japan. The sizing material is prepared from pulverised roots by soaking in water and filtering. The mucilage in the dispersed form exhibits a network structure which

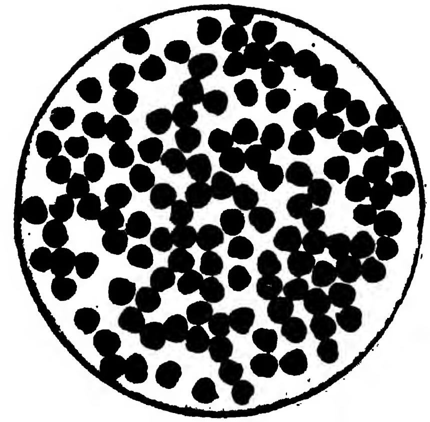


FIG. 53. HIBISCUS MANIHOT—SEEDS

expands on dilution and contracts on concentration. At high temperatures, the structure is loosened and the viscosity decreases. Roots which have been stored for long periods give a mucilage of inferior quality and poor viscosity. A number of processes have been patented for the preparation of non-ageing mucilage from the roots by the use of stabilising agents. The mucilage resembles sodium alginate in many respects (Burkill, I, 1167; *Chem. Abstr.*, 1949, **43,** 1974, 1975; 1952, **46,** 10654; 1953, **47,** 3530, 5148, 11782).

The mucilage is a polyrhamnogalacturonide. On hydrolysis with dilute hydrochloric acid, it yields galacturonic acid, rhamnose and an aldobionic acid consisting of galactose and rhamnose. A polysaccharide composed of glucose, xylose and arabinose has been separated from the crude mucilage (*Chem. Abstr.*, 1952, **46,** 7351; 1953, **47,** 8194, 11782).

The seeds yield a fatty oil, the characteristics of which are indicated in Table 3. The oil (iod. val., 105.9) contains 19% saturated acids (chiefly $C_{16}$-acids) and 81% liquid acids (linoleic and oleic with a small quantity of linolenic) (*Chem. Abstr.*, 1953, **47,** 9636).

The plant yields a tough fibre resembling jute in physical and chemical characteristics. It may be used in the manufacture of inferior types of wrapping cloth, strings and chords. It is creamy in colour, stiff, but not lustrous. The physical characteristics of the fibre are as follows: length of the ultimate fibres, 1.6 mm.; length/diameter, 122; intrinsic strength, 1.619±0.064 g./denier; and elongation at break, 7.40%. Analysis of the fibre gave the following values: ash, 0.671; fat and wax, 0.343; cellulose, 87.37; lignin, 11.59; and nitrogen, 0.139% (Betrabet, *J. sci. industr. Res.*, 1956, **15C,** 146).

The leaves are reported to be eaten in Celebes. The bark is emmenagogue; leaves and roots are made

into a plaster and used as poultice for boils, sores, sprains and inflammations (Burkill, I, 1167; Kirt. & Basu, I, 339; Fl. Assam, I, 144; Cheo, *Bot. Bull. Acad. sinica*, 1949, **3**, 135).

**H. mutabilis** Linn. CHINESE ROSE, CHANGEABLE ROSE, CHANGEABLE HIBISCUS, COTTON ROSE, CONFEDERATE ROSE

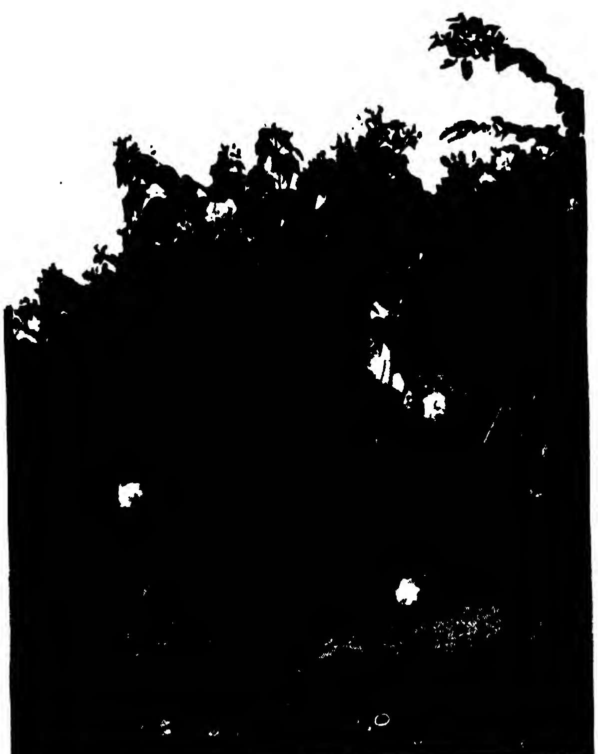
D.E.P., IV, 242; Fl. Br. Ind., I, 344.

HINDI—*Shalapara, sthal kamal;* BENG.—*Sthalpadma;* TAM.—*Irratai-vellaichembarattam, sembarattai;* KAN.—*Bettada tavare, neladavare, suryakanti;* MAL.—*Chinapparatti, hinaparutti;* ORIYA—*Sthalopidmo, tholopodmo.*

PUNJAB—*Gul-i-ajaib.*

A large bushy shrub or small tree, about 8 ft. high, found almost throughout India. Leaves 4–9 inches in length, hairy, deeply cordate, 3–5 lobed: flowers 3–5 inches in diam., white or pink in the morning turning red by night; capsules sub-globose, 0.8 inch in diam., hairy; seeds reniform, brown, hispid.

*H. mutabilis* is said to be a native of China. It is cultivated in Indian gardens as an ornamental plant for its beautiful flowers, which may be single or double; the double-flower type is more common. The plant is propagated by cuttings or seeds. Flowering takes place in profusion in constant succession during September and October. Annual pruning (in April) induces profuse flowering (Bor & Raizada, 235; Benthall, 39; Gopalaswamiengar, 271).



*F.R.I., Dehra Dun. Photo: M. Bakshi*

FIG. 54. HIBISCUS MUTABILIS

The bark of the plant yields a strong fibre of inferior quality. In China, the leaves and flowers of the plant are considered expectorant, cooling, antidotal to poisons and anodyne. They are recommended for persistent coughs, menorrhagia, dysuria and wounds caused by burns and scalds. An infusion of the flowers is given in pectoral and pulmonary complaints. The leaves are used in poultices for swellings. The plant is considered emollient and used in fistulae, pustules and tumours [Kirt. & Basu, I, 340; Quisumbing, 576–77; *J. sci. Res. Indonesia*, 1952, **1** (suppl.), 26].

**H. rosa-sinensis** Linn. SHOE FLOWER, CHINESE HIBISCUS

D.E.P., IV, 242; C.P., 629; Fl. Br. Ind., I, 344.

SANS.—*Japa, java, rudra pushpam;* HINDI—*Jasut, jasum;* BENG.—*Joba;* MAR.—*Dasindacha phula, jasavanda;* GUJ.—*Jasuva;* TEL.—*Java pushpamu, dasana;* TAM.—*Semparuthi;* KAN.—*Dasavala;* MAL.—*Chembarathi;* ORIYA—*Mondaro.*

ASSAM—*Joba;* PUNJAB—*Jasum.*

An evergreen woody, glabrous, showy shrub, 5–8 ft. high; leaves bright green, ovate, entire below, coarsely toothed above; flowers solitary, axillary, bell-shaped, large, 4–6 inches in diam. with pistil and stamens projecting from the centre; capsules roundish, many-seeded.

*H. rosa-sinensis* is a native of China. It is grown as an ornamental plant in gardens throughout India and often planted as a hedge or fence plant. It can be planted with advantage in group planting of shrubs or for beautifying parks and grassy plots. Numerous types adapted to sunny, semi-shady and shady locations and with single and double flowers of red, yellow, white, magenta, cherry and striped colours are in cultivation. Many of them are hybrids with allied species, such as *H. tiliaceus* and *H. schizopetalus.*

The plant thrives in any type of soil, but good results are obtained in well prepared, manured and irrigated soils. It can be propagated by cuttings, preferably from mature wood of current growth. It blossoms almost throughout the year and seldom sets

seeds under cultivation. A wet rot disease of flowers, caused by *Choanephora infundibulifera* (Curry) Cunningham has been reported (Bailey, 1947, II, 1488; Bor & Raizada, 237–38: Cowen, 111; Macmillan, 106: Gopalaswamiengar, 272; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 93: Mundkur, 31; *Indian J. agric. Sci.* 1950, **20,** 107).

The flowers are reported to be eaten, raw or pickled in China and Philippines. Analysis of the edible part of the flowers (61.6%) gave the following values: moisture, 89.8; nitrogen, 0.064; fat, 0.36; and crude fibre, 1.56%: calcium, 4.04; phosphorus, 26.68; and iron, 1.69 mg./100 g. The flower contains thiamine (0.031 mg.%), riboflavin (0.048 mg.%), niacin (0.61 mg.%) and ascorbic acid (4.16 mg.%) (Neal, 489; Intengan *et al.*, *Philipp. J. Sci.*, 1955, **84,** 343).

Crushed flowers yield a dark-purplish dye which was formerly employed for blackening shoes. In China and other countries, the dye is used for colouring hair, eyebrows, foods and liquors. The flowers contain an anthocyanin pigment, cyanidin diglucoside. The leaves contain carotene (7.34 mg./100 g. of fresh material) and are used as fodder (Macmillan, 418; Quisumbing, 577: Neal, 489; *Chem. Abstr.*, 1951, **45,** 4786: *Tea Encyclopaedia,* O/4, Ser. No. 11, 1947; Acharya & Malpoorwala, *J. Univ. Bombay, N.S.*, 1952, **21,** 47).

The flowers are considered demulcent, emollient, refrigerant, aphrodisiac and emmenagogue. They are made into a paste and applied to swellings and boils. A decoction of the flowers is given in bronchial catarrh. They are fried in ghee and given in menorrhagia. The leaves are emollient, aperient, anodyne and laxative. A decoction of the leaves is used as a lotion in fevers. Mixed with the juice of *Vernonia cinerea* Less., it is used in Malaya to stimulate expulsion after child birth. The root is used in indigenous medicine and sold in bazaars as a substitute or adulterant of the root of *Althaea officinalis* Linn. The root occurs in the entire or nearly entire condition, 2 to 5 cm. in length and 1 to 3 mm. in diam., with indistinct odour and slightly sweetish, but acid, taste. It is demulcent and used for coughs. In Malaya, a decoction of the root is used for venereal diseases and fevers. Fresh root juice is given for gonorrhoea and powdered root for menorrhagia. The root is used in Mysore for certain diseases of cattle (Kirt. & Basu, I, 335; Nadkarni, I, 631: Burkill, I, 1169; Quisumbing, 577; Chandrasena, 47: Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 37).

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FIG. 55. HIBISCUS SABDARIFFA—FLOWERING BRANCH

**H. sabdariffa** Linn. ROSELLE, JAMAICA SORREL, RED SORREL

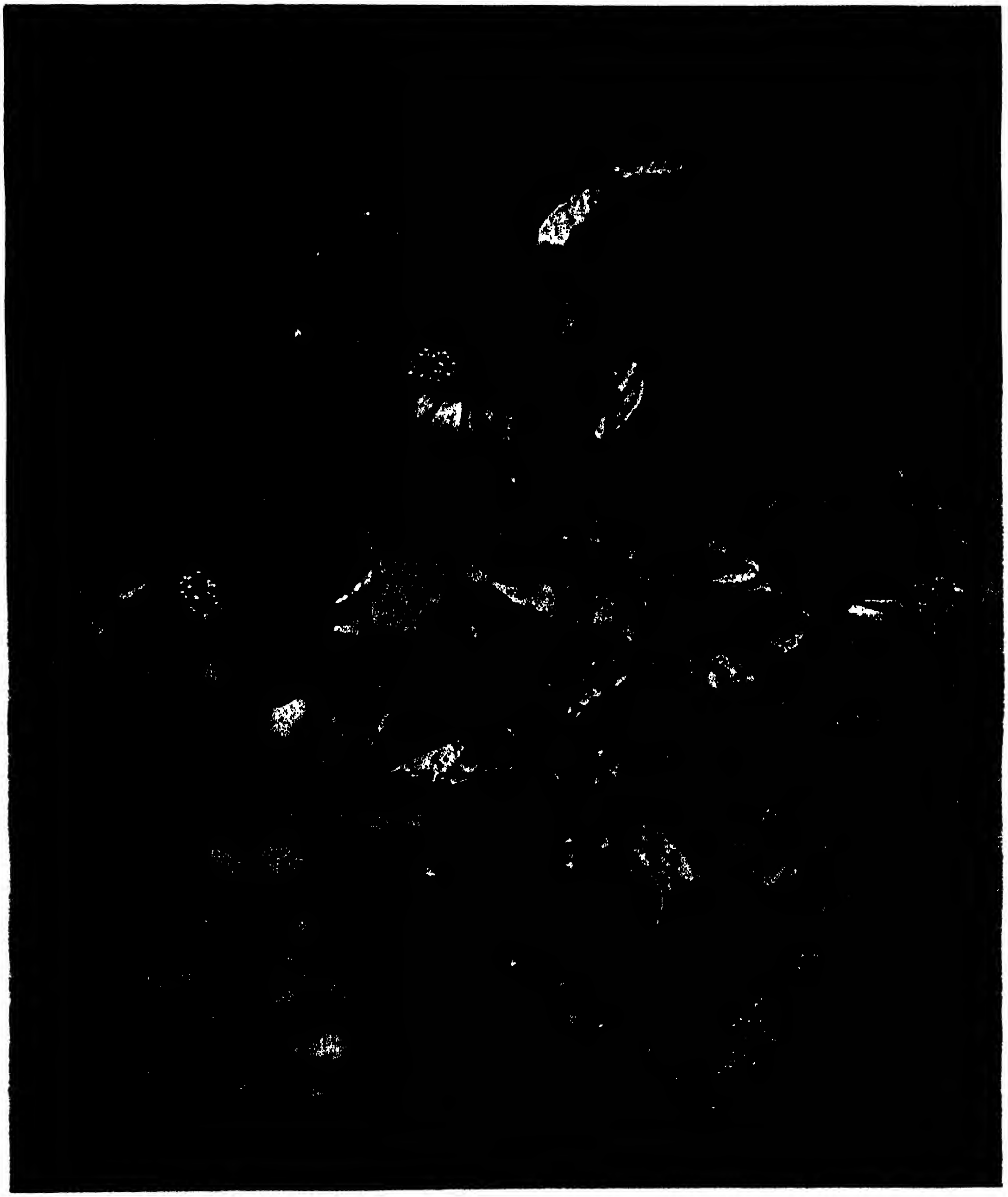
D.E.P., IV, 243; C.P., 629; Fl. Br. Ind., I, 340.

HINDI—*Lal-ambari, patwa;* BENG.—*Lal-mista, patwa, chukar;* MAR.—*Lal-ambadi, patwa;* TEL.—*Yerra gogu;* TAM.—*Pulichchai kerai, gogu;* KAN.—*Pulachakiri, pundibija;* MAL.—*Polechi, pulichchai.*

ASSAM—*Chukiar.*

An annual erect shrub with red or green stem, practically unbranched or with branches near the base; stem glabrous or slightly hairy with minute tubercles; leaves serrate, lower leaves ovate and undivided, upper ones palmately 3–5 lobed; flowers large, yellow with dark crimson eye: epicalyx united at the base and adnate to calyx: calyx connate below, free above, dark purple, fleshy; capsules ovoid, pointed, villous; seeds numerous, large, reniform, black-brown, covered, with minute, stout, stellate hairs.

A native of tropical Africa or Asia, *H. sabdariffa* is now found under cultivation throughout the tropics



HIBISCUS ROSA-SINENSIS — FLOWERING BRANCH

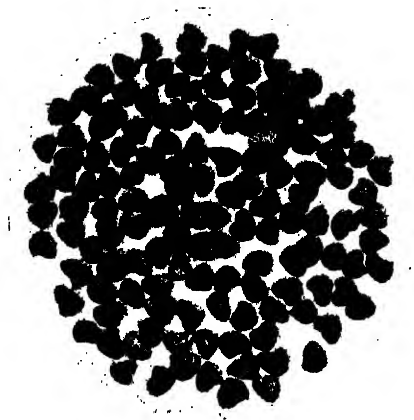


FIG. 56. HIBISCUS SABDARIFFA—SEEDS

and comprises a large number of cultivated types which, on the basis of their growth habit or end use, are classified broadly under two varieties, *H. sabdariffa* var. *sabdariffa* and *H. sabdriffa* var. *altissima.* The former includes types which are generally branched and pigmented, and cultivated for the edible calyces ; the latter includes tall-growing, practically unbranched types bearing inedible calyces, mainly cultivated for the stem fibre (Roselle).

—var. **sabdariffa**

Based on plant colouration, the edible types can be classified under four races, namely, race *ruber** ; race *albus** ; race *intermedius** ; and race *bhagalpuriensis**. With the exception of a slight difference in the form of the calyx in race *bhagalpuriensis,* all the races are identical in morphological and agricultural characters ; they also breed true. On account of their bushy and branching habit, they are not useful for fibre extraction. Race *ruber* is considered to be the most useful for culinary purposes. In the Philippines, four edible types have been isolated, viz., *Victor, Rico, Archer* and *Temprano ;* these are considered to be synonymous with races differentiated in India (Haarer, 79, 82 ; Howard & Howard, *Mem. Dep. Agric. India, Bot.*, 1911, **4,** 9 ; Crane, *Econ. Bot.*, 1949, **3,** 89 ; Wester, *Philipp. agric. Rev.*, 1914, **7,** 266).

The edible types are cultivated in warm countries, particularly in the Philippines, Malaya and Indonesia, for their calyces. In India, they are grown in Punjab, U.P., Bihar, Bengal, Assam, Orissa, Bombay, Mysore, Andhra and Madras as a monsoon crop (April-November). Seeds are sown on well-prepared seed beds and the seedlings when 4–5 in. high are transplanted in the field in rows 5–6 ft. apart, the distance between the plants in the row being 3–4 ft. The plants may also be propagated by rooting shoot cuttings in August-December. Such plants attain a much shorter height than transplanted seedlings and are preferred for planting as intercrop in orchards (Firminger, 245 ; Gollan, 86 ; Brown, 1941, II, 416 ; Milsum, *Bull. Dep. Agric. F.M.S.*, No. 20, 1919, 68 ; Sambamurthy, *Madras agric. J.*, 1953, **40,** 503).

The capsules are ready for picking in November-December and the picking season lasts for about two months. The capsules begin to mature progressively from the lower to the upper portion of the plant. The edible fleshy calyces mature rapidly and are ready for picking within 15–20 days after blossoming. They are gathered when tender, plump, fleshy, crisp and deep red in colour. Prompt picking of calyces extends the flowering period, prolongs harvest, and increases yield. After harvesting, the plants are allowed to remain in the field until the capsules in the lower and middle tiers become mature ; they are then cut, dried and threshed for seed (Macmillan, 259 ; Crane, loc. cit. ; Sambamurthy, loc. cit.).

The yield of calyces averages to 3 lb. per plant. A yield of 5,000–7,000 lb. of calyces per acre has been recorded ; under favourable conditions, it may be double. The yield recorded in Coimbatore (Madras State) is 0.5 lb. per plant. Plants raised from cuttings give a relatively low yield—about half that obtained from transplanted seedlings (Milsum, loc. cit. ; Sambamurthy, loc. cit. ; Crane, loc. cit.).

*Uses*—Tender leaves and stalks are eaten as salad or used for seasoning curries. They are acid to taste and may be used for the preparation of jelly, flavouring extracts, syrup and wine. Analysis of fresh leaves gave the following values: moisture, 86.2 ; protein, 1.7 ; fat, 1.1 ; carbohydrate, 10.0 ; mineral matter, 1.0 ; calcium, 0.18 ; phosphorus, 0.04 ; and iron, 0.0054%. The acid content (calculated as malic acid) of leaves is 1.25% and that of stem, 0.6% (Wester, *Philipp. agric. Rev.*, 1920, **13,** 89 ; *Hlth Bull.*, No. 23, 1951, 32).

The calyces are rich in acid (3.74%, calculated as citric acid) and pectin (3.19%) and are useful for jellies, chutneys and preserves. They make a jelly of good quality with a bright red colour and may be used in blends with highly flavoured fruits for the preparation of jelly. They are also used in soups, puddings, cakes and pies and for colouring syrups and liquors. They may also be dried (yield, 1 lb. per 11 lb. of fresh calyces) and stored in air-tight

*Though designated as varieties by Howard & Howard and by other authors following them, they are no more than cultivated races with indistinguishable botanical characteristics.

containers. Analysis of fresh calyces gave the following values: moisture, 88.26; crude protein, 1.46; ether extr., 1.97; carbohydrates, 5.86; crude fibre, 1.58; ash, 0.87; calcium, 0.108; phosphorus, 0.052; and iron, 0.021%; manganese, aluminium, magnesium, sodium and potassium are present in traces. Reducing sugars (0.82%) and sucrose (0.24%) are also present. The principal water-soluble acids present in the calyces are citric acid and *d*-malic acid; tartaric acid and hibiscus acid (a lactone of hydroxy citric acid; $C_6H_6O_7$: m.p., 181–83°) are present. The calyces contain appreciable quantities of mucilage, calcium citrate and ascorbic acid. They also contain a substance which reduces indophenol dye, but does not possess antiscorbutic properties (Singh & Dutt, *Indian J. agric. Sci.*, 1941, **11**, 1006; Hill, 33; Milsum loc. cit.; Mayadas, *Punjab Fr. J.*, 1947, **11**, 169; Sambamurthy, loc. cit.; Wester, loc. cit.; *Chem. Abstr.*, 1941, **35**, 8209; 1939, **33**, 7491; 1944, **38**, 2708).

The calyces contain gossypetin and hibiscin chloride ($C_{26}H_{29}O_{16}Cl$. $3H_2O$: m.p., 178°); the latter on hydrolysis yields glucose, pentose and delphinidin chloride. Hibiscin chloride is reported to possess antiseptic properties (*Chem. Abstr.*, 1936, **30**, 1180; 1941, **35**, 8209; Thorpe, VI, 90).

An infusion of the calyces is used for preparing a beverage of agreeable acid taste for medicinal use. It is cooling and refreshing; it aids digestion and is useful in bilious conditions; it has diuretic and choleretic properties and acts as an intestinal antiseptic; as a mild laxative, it is used in heart and nerve diseases, high blood pressure and calcified arteries. The therapeutic properties of the beverage are attributed to the presence of acids and the emollient and sedative mucilage. Though reported to be antiscorbutic, it is ineffective against scurvy (*Chem. Abstr.*, 1936, **30**, 817, 1180; 1939, **33**, 3891, 7491; 1942, **36**, 4166; 1944, **38**, 2708).

Analysis of the fruits gave the following values: moisture, 76.4; total sugar, 2.28; reducing sugars, 1.05; pectins, 1.02; and acids (as citric), 1.03%. Jellies prepared from the fruits are somewhat slimy and of loose consistency (Singh & Dutt, loc. cit.).

The seeds are bitter to taste, but are reported to be eaten in some parts of Africa. They contain: moisture, 12.9; nitrogen, 3.29; and fatty oil, 16.8%; cellulose (16.8%), pentosans (15.8%) and starch (11.1%) are present. The expressed oil is brownish yellow in colour with a sweetish sickly odour. It resembles cottonseed oil (Table 3). The residual cake is rich in protein; it is used as cattle feed. Analysis of the seed cake gave the following values: nitrogen, 3.92; phosphorus ($P_2O_5$), 2.24; and potassium ($K_2O$), 2.02% (Burkill, I, 1171; Georgi, *Malay. agric. J.*, 1923, **11**, 223; *Chem. Abstr.*, 1941, **35**, 4157; Rao, *Indian Soap J.*, 1952–53, **18**, 90).

The flowers yield a yellow dye of little commercial value. The chief pigment is a flavonol glycoside, hibiscitrin [3-monoglycoside of hibiscetin: $C_{21}H_{20}O_{14}$; m.p., 238–40° (decomp.)]; hibiscetin [3:5:7:8:3′:4′:5′-heptahydroxy flavone, $C_{15}H_{10}O_9$; m.p., 250° (decomp.)], gossypitrin and sabdaritrin [$C_{21}H_{20}O_{13}$. $3H_2O$; m.p., 251–53° (decomp.)] are also present. The waxy matter separated from the flowers contains a phytosterolin [$C_{35}H_{60}O_6$: m.p., 251–52° (decomp.)], hydrocarbons (chiefly $C_{27}$-hydrocarbons) and minor quantities of sitosterol. The phytosterolin gives on hydrolysis a sitosterol ($C_{29}H_{50}O$: m.p., 136–37°) and glucose (Rao & Seshadri, *Proc. Indian Acad. Sci.*, 1942, **15A**, 148; 1942, **16A**, 323; Rao *et al.*, ibid., 1944, **19A**, 88; Murti & Seshadri, ibid., 1945, **22A**, 289; Rao & Seshadri, ibid., 1948, **27A**, 104).

The stalks yield a fibre (ultimate fibre, 1.2–6.0 mm. long × 0.01–0.03 mm. diam.) used locally for cordage, rope and gunnies. Ropes made from the fibre are strong (dry strength, 41 kg. and wet strength, 53 kg.) (Harris, 115, 136).

-var. **altissima** Wester

A tall, vigorous and practically unbranched plant often attaining a height of 10–16 ft.; calyces fibrous, spiny and inedible. This variety is indigenous to West Africa and is grown widely in the Philippines, Indonesia and, more recently, in parts of S. Africa and N. and S. America. It was introduced into India as a single seed in a consignment of seeds of *Calopogonium mucunoides* Desv. from Java. The seedling raised from the seed was designated 'New Hibiscus' and was subsequently identified as *H. sabdariffa* var. *altissima*; a hybrid evolved by crossing it with race *albus* gives a fibre of superior fineness and appearance (Haarer, 105; Shaw & Kashi Ram, *Agric. Live-Stk India*, 1934, **4**, 476; Wester, *Philipp. agric. Rev.*, 1914, **7**, 266; Haarer, 82, 99; Deshpande, *Sci. & Cult.*, 1950–51, **16**, 237; *World Crops*, 1952, **4**, 70; Kirby, *Bull. imp. Inst., Lond.*, 1947, **45**, 97; Khan, *Agric. J. India*, 1930, **25**, 210; *Agric. Anim. Husb. India*, 1936–37, 89).

Roselle has attained prominence as a jute substitute and attempts are being made to extend its cultivation in India, especially in areas which are not favourable for jute cultivation. It is particularly successful in

Bengal; it is cultivated also in Bihar, Assam, Madras and Andhra. In the last State, it has spread rapidly and is grown in preference to *H. cannabinus* or *H. sabdariffa* var. *sabdariffa* as it yields more fibre. It withstands drought and is not damaged by cattle (Deshpande, loc. cit.; Rama Rao, *Madras agric. J.*, 1950, **37**, 285).

The plant is well adapted to all types of soils, but thrives best in moderately fertile, well-drained, permeable soil. It tolerates a certain degree of acidity or alkalinity in the soil, but is sensitive to frost. It requires a moist climate, high temperature throughout the growth period, and medium rainfall; vegetative growth is vigorous during the season of long days and the plant begins to flower and fruit as the days begin to shorten (Haarer, 99; Kirby, loc. cit.; Deshpande, loc. cit.; Crane, loc. cit.; Haarer, *Fibres*, 1956, **17**, 105).

In Madras and Andhra, roselle is grown mostly on dry land in rotation with other crops; it is cultivated in wet lands only to a small extent. Seeds are sown broadcast or by drills in May-June with the onset of rains. Line sowing with interculture between lines gives good results. The spacing between plants in the row is usually 6 in., the distance between rows being 4–12 ft. The seed rate is 8–10 lb per acre when sown broadcast. The crop responds well to applications of nitrogenous manures in combination with potash and phosphatic fertilizers. In Java, the Philippines and Africa, ammonium sulphate is applied at the rate of 450 lb. per acre and a green manure crop, e.g. *Mimosa invisa* Mart., usually grown. In Andhra, it is usual to apply heavy doses of manure; tank silt is applied at the rate of 40–50 cart loads per acre and sheep are penned on the field. Application of groundnut cake at the rate of 2 bags per acre has given good results (Rama Rao, loc. cit.; Datta *et al.*, *Jute Bull.*, 1955–56, **18**, 181; Crane, loc. cit.; *Jute Bull.*, 1950–51, **13**, 495).

*Diseases and pests*—A stem rot caused by *Sclerotinia sclerotiorum* (Lib.) Mass. affects crops left over for seed purposes after the main crop is harvested for fibre. The disease is prevalent in Bihar and appears in January when the temperature is low. It manifests itself as straw-brown patches on the main stem or on branches of the inflorescence. As a control measure, sclerotia from the seed are hand-picked and ploughed deep into the soil. Rotation with a cereal crop and use of early maturing and resistant types are recommended. Roselle is also affected by *Phoma sabdariffa* and *Cercospora hibiscae* (Mundkur, 126–28; *Indian J. agric. Sci.*, 1934, **4**, 758; *Rep. Indian Jute Comm.*, 1948–49, 14).

The crop is affected by a number of pests, of which *Rhenacoccus hirsutus* Gr. is the most serious. This pest attacks the apical region of the plant and sucks the juice, as a result of which growth is affected and yields of fibre and seed are reduced. The pest is controlled by spraying the plants with nicotine sulphate. The grub of *Scymnus* (*Pullus*) *pallidicollis* Muls. is predatory on the eggs, nymphs and adult females of the pest. *Podagrica apicefulva* has also been reported to attack roselle (Dutt *et al.*, *Indian J. agric. Sci.*, 1951, **21**, 231; *Rep. Jute agric. Res. Inst., Indian Jute Comm.*, 1951–52, 114).

*Harvesting*—The crop is harvested at the bud stage, when both outturn and quality of fibre are good. Stalks are tied into bundles of convenient size, left on the field for 3–4 days, and retted as in the case of *H. cannabinus*. A more economical and satisfactory method for extracting the fibre has been tried in Ceylon; the bark is stripped off the cortex, tied into bundles and retted in tanks. The retted fibre is washed in running water to remove foreign matter, dried in the sun, combed and baled. The average yield of fibre is reported to be 1,000 lb. per acre. Yields ranging from 1 to 6 tons per acre have been recorded under favourable conditions (Haarer, 108–11; Kirby, loc. cit.; *Rep. Indian Jute Comm.*, 1948–49, 12; Crane, loc. cit.; Rama Rao, loc. cit.; Shaw & Kashi Ram, *Agric. Live-Stk India*, 1934, **4**, 476; Bally, *Ciba Rev.*, No. 108, 1955, 3904; *Rep. Jute agric. Res. Inst., Indian Jute Comm.*, 1951–52, 100).

For purposes of seed collection, a part of the field is left unharvested and pods allowed to attain full maturity. This practice is uneconomical. Separate planting with a liberal distance between plants gives better yields and better seeds (Crane, loc. cit.; Haarer, 106, 110).

*Fibre characteristics*—Roselle fibre resembles jute and bimli fibre in general appearance and characters (Table 2). It has a length of about 12 ft., the ultimate fibre being 1.2–3.3 mm. long × 0.01–0.03 mm. diam. It is silky, soft, lustrous, white to pale yellowish brown in colour, with chemical and physical properties similar to those of jute. It is comparable to jute in strength and durability but is somewhat harsh and coarse. It can be mixed with jute and spun on jute machinery. Being less flexible than jute, preliminary softening and longer batching treatment are necessary (Haarer, 86–87; *Bull. imp. Inst., Lond.*, 1930, **28**, 284; Sircar, *Misc. Bull. Indian Coun. agric. Res.*,

No. 66, 1948, 31 ; Deshpande, loc. cit. ; Kirby, loc. cit. ; Haarer, *Fibres*, 1956, **17**, 105).

Roselle fibre is employed for sacking, cordage, rope, fishing nets and generally for all purposes for which jute is used. Bags made of roselle fibre are extensively employed in Java for packing sugar. The stalks left over after fibre extraction are used as fuel (Crane, loc. cit. ; Kirby, loc. cit. ; Rama Rao, loc. cit.).

Data relating to the acreage and production of roselle are not separately available ; the figures given under mesta (Table 4) include both roselle and bimli fibre. Small quantities of the fibre are consumed locally, but the major part of the production in Andhra is consumed by jute mills in Visakhapatnam district (Rama Rao, loc. cit.).

**H. surattensis** Linn.

D.E.P., IV, 246 ; Fl. Br. Ind., I, 334.

Tel.—*Mullu gogu* ; Tam. *Kashlikirai*.

Bombay *Ranbhendy* ; Mikir *Hansrong*.

A weak-stemmed, intensely prickly, trailing herb, found in Delhi, Bengal, Assam, Andhra, Konkan and the west coast from Kanara to Tinnevelly. Leaves somewhat hairy, deeply palmately 3–5 lobed with serrate margin ; flowers large, yellow with dark centre ; capsules ovoid, hairy ; seeds hairy.

FIG. 57. HIBISCUS SURATTENSIS—FLOWERING AND FRUITING BRANCH

The plant is raised from seeds. It flowers in September-October and the fruits ripen in December-February (Firminger, 606 ; Cowan & Cowan, 21).

The stem yields a strong fibre of good quality. The leaves are acidic and are eaten after cooking or used in salad and as condiment with meat and fish. They are reported to be used for constipation and cough ; a decoction is used for skin complaints. A lotion prepared from leaves and stems is given in the treatment of venereal sores and urethritis ; an infusion is used as injection for gonorrhoea. Flowers are considered emollient and pectoral in Reunion. (Burkill, I, 1172 ; Dalziel, 130 ; Reddy & Janaki Devi, *Andhra agric. J.*, 1954, **1**, 365 ; Brown, 1941, II, 418 ; Quisumbing, 581 ; Watt & Breyer-Brandwijk, 118 ; Kirt. & Basu, I, 338).

**H. syriacus** Linn. Rose of Sharon, Shrubby Althaea

Fl. Br. Ind., I, 344 ; Bor & Raizada, Pl. 90 & 91.

Beng.—*Swet jaba*.

Bihar & Orissa—*Gurhul* ; Punjab—*Gurhal*.

A deciduous, much-branched shrub, 10 ft. high, sometimes attaining a height up to 20 ft. Leaves glabrous, sub-rhomboid, 3-lobed ; flowers bell-shaped, solitary in the axils, about 3 in. across ; capsules oblong, obtuse, slightly hispid ; seeds pilose.

The plant is indigenous to China. It is cultivated in gardens throughout India for its handsome flowers which vary in colour from blue-purple to violet-red, buff and white. Numerous horticultural types with single, semi-double or double flowers are known ; there are also forms with variegated leaves.

The plant is frost-hardy and stands hard pruning. It can be grown on any good soil. It thrives best on hills and in the cooler parts of the plains. Propagation is by cuttings planted in winter or early autumn ; it may also be propagated by layers or grafting ; flowering takes place in June-August (Blatter, *J. Bombay nat. Hist. Soc.*, 1930, **34**, 627 ; Bailey, 1947, II, 1488 ; Chittenden, II, 996 ; Bor & Raizada, 239 ; Fl. Assam, I, 145 ; Biswas, *Rec. bot. Surv. India*, 1940, **5**, 420).

The stem yields a strong fibre. Tender leaves are reported to be used as a substitute for tea in China. The leaves are considered stomachic. White flowers are edible. A decoction of the flowers is considered diuretic and used for itch and other skin diseases in Malaya. It is given for dysentery in Indo-China. The

bark and root are mucilaginous, demulcent and antifebrile; they are used in diarrhoea, dysentery and dysmenorrhoea. Seeds are used in headache and colds; mixed with pig marrow, they are used in applications for ulcers (Bamber, 89; Burkill, I, 1172; Cheo, *Bot. Bull. Acad. sinica*, 1949, **3**, 153, 135; Quisumbing, 582).

**H. tiliaceus** Linn. COAST COTTON TREE, YELLOW MALLOW TREE

D.E.P., IV, 247; C.P., 629; Fl. Br. Ind., I, 343.

HINDI & BENG.—*Bola, chelwa*; MAR.—*Belapata*; TEL.—*Etegogu*; TAM. & MAL.—*Nirparathi, attu parathi*; ORIYA—*Baniah*.

ANDAMAN ISLANDS—*Safed chilka*.

A much-branched shrub or small tree, 20–30 ft. high, found along sea shores, borders of mangrove swamps and tidal streams throughout the tropics. Leaves roundish, crenulate, leathery; flowers yellow with a crimson centre, turning red on withering; capsules hairy, ovoid; seeds reniform, black.

The plant is found along the eastern and western coasts of India near backwaters and banks of tidal streams and mangroves. It is particularly common in Sundarbans and Andaman Islands, where it is found in places subject to flooding by sea water and forms dense thickets near the shore. The plant is grown in the interior along river banks for checking soil erosion. It is also planted in gardens for its ornamental foliage and flowers. It is propagated by seeds and cuttings and flowers sporadically almost throughout the year, but profusely in cold and hot seasons (Parkinson, 96; Burkill, I, 1172; Brown, 1941, II, 420; Dalziel, 131; Benthall, 36; McCann, 3).

The plant is valued for its bark fibre used locally for cordage, ropes and mats. The fibre is more resistant to water than sunn hemp and jute, and gains considerable strength and durability when coated with tar. The fibre can be extracted even from green or unretted stalks by stripping the bark, exposure to the sun for a day or two, and beating with a wooden mallet or stick to remove the outer layers. Retting gives a fibre of better appearance (Nicholls & Holland, 532; Burkill, I, 1172–73; Manson, *Indian For.*, 1905, **31**, 347; Brown, 1941, II, 420; Dalziel, 131).

FIG. 58. HIBISCUS TILIACEUS—FLOWERING BRANCH

The fibre is used particularly in Andaman Islands and the Sundarbans for ropes and cordage. Strings and cordages made from the fibre are used for fishing lines and nets. In the Andamans, it is used for harpoons employed in hunting dugong and for elephant gear. In Portuguese East Africa, it is used for hunting hippopotamus. Mats are woven from the fibre in Ceylon and in some Pacific Islands. In Caroline Islands, the inner bark is split into narrow strips and woven into aprons (Burkill, I, 1173; Brown, 1941, II, 420; Dalziel, 131; Parkinson, 96).

The bark may be used for the manufacture of wrapping paper. The fibre is of short length and the pulp obtained is inferior in quality. The wood is whitish grey, soft, light (35–38 lb./cu.ft.) and flexible. It is durable in sea water and useful for planking and light boats. In Malaysia, it is employed for floats of fishing nets, catamarans, household implements, for parts of carts and axe-handles. It is reported to be used in West Indies for cabinet work, flooring, panelling and fancy work. In India, it is used as fuel; it can be used in place of walnut for gunstock (Burkill, I, 1173; *For. Abstr.*, 1952, **13**, 448; Dalziel, 131; Howard, 60; Neal, 491; Record & Hess, 351; Gamble, 88).

The leaves are used as cattle feed. Analysis of leaves gave the following values (dry matter basis): protein, 11.8; fat, 4.8; starchy matter, 52.1; crude fibre, 21.5; and ash, 9.9% (Burkill, I, 1174; Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 201).

An infusion of the leaves is used as a lotion for ulcers and wounds; the leaves are considered laxative and resolvent. Flowers are boiled in milk and used as a remedy for earache. The bark is emetic. The mucilage, obtained by macerating fresh bark in water, is given in dysentery. The root is febrifuge, aperitive, emollient, sudorific, diuretic and laxative; it is used in the preparation of an embrocation for rheumatism and lumbago. An infusion of the seeds is used as an emetic in Brazil; the leathery coat of the seeds is reported to contain an active principle (Brown, 1941, II, 420; Kirt. & Basu, I, 334; Nadkarni, I, 633; Quisumbing, 583).

**H. trionum** Linn. TRAILING HOLLYHOCK, BLACK-EYED SUSAN

Fl. Br. Ind., I, 334; Blatter, I, Pl. 15, Fig. 4.

A pubescent herb, 1–2 ft. high, found throughout India ascending to a height of 6,000 ft. in western Himalayas. Leaves variable, lower leaves orbicular, undivided, upper deeply 3–5 lobed; flowers c. 1½ inches in diam., pale yellow with dark purple centre; capsules oblong, obtuse, hairy; seeds rounded on the back, glabrous.

*H. trionum* is a common plant with showy flowers, occurring widely as a weed of cultivation. It is propagated by seeds. It prefers black cotton soil, but may be grown also in light sandy soil. The plant comes into blossom early and produces seeds abundantly (Collett, 60; Blatter, *J. Bombay nat. Hist. Soc.*, 1930, **34,** 629; Firminger, 605).

The plant is used in southern Africa for round worm. It is reported to be poisonous to stock, particularly horses. In China and Malaya, the dried leaves are considered stomachic. An infusion of the flowers is used for itch and painful skin diseases; it is also considered diuretic. The seeds contain 21.8–23.8% of a fatty oil (Watt & Breyer-Brandwijk, 117; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 102; Kirt. & Basu, I, 338; *Chem. Abstr.*, 1936, **30,** 811).

Other species of *Hibiscus* known to yield fibre useful for cordage, twine, rope and fishing lines are: *H. eriocarpus* DC. (syn. *H. platanifolius* Sweet, *H. collinus* Roxb.), *H. lunariifolius* Willd., *H. radiatus* Cav., *H. tricuspis* Banks and *H. vitifolius* Linn. The petals of *H. vitifolius* are rich in flavonols with high tinctorial properties (Matthews, 347; *Bull. imp. Inst., Lond.*, 1947, **45,** 126; Dalziel, 129; Rao & Seshadri, *Proc. Indian Acad. Sci.*, 1946, **24A,** 352).

The following species are considered to be of ornamental value: *H. eriocarpus*, *H. schizopetalus* (Mast.) Hook. f., and *H. tricuspis*. *H. fragrans* Roxb., a small tree of Assam, bears white fragrant flowers [Firminger, 605–6; Bor & Raizada, 236; Cowen, 113; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(5), suppl., 64].

*H. tuberculatus* Pal & Singh, a wild species recently recorded from Delhi, Uttar Pradesh and Rajasthan, is resistant to mosaic and to fruit borer attack. It has been used in hybridisation with *H. esculentus* (Pal *et al.*, *Bot. Gaz.*, 1951–52, **113,** 455).

The root of *H. crinitus* G. Don = *Abelmoschus crinitus* Wall. (syn. *H. cancellatus* Roxb.) is reported to be edible. The leaves of *H. radiatus* are used as vegetable or pot-herb. The green capsules of *H. micranthus* Linn. f. are eaten. *H. micranthus* and *H. radiatus* are reported to possess medicinal properties [Haines, II, 64; Burkill, I, 1168; Duthie, I, 89; Kirt. & Basu, I, 327; *J. sci. Res. Indonesia*, 1952, **1** (suppl.), 26].

**Hickory Nuts** — *see* **Carya**

## HIERACIUM Linn. (*Compositae*)

Fl. Br. Ind., III, 399.

A genus of herbs distributed in the cooler parts of the world, chiefly in the temperate, alpine and arctic regions of the northern hemisphere. Five species occur in India.

*H. virosum* Pall. is a medium-sized, perennial herb with a stout stem, found in Kashmir at altitudes of 7,000–8,000 ft. Leaves sessile, crowded gradually diminishing upwards, oblong-ovate, 1–3 in. long, cordate, toothed; flower-heads yellow, in terminal umbellate corymbs.

The plant is used as aperient and vulnerary in Spain. It is said to be poisonous (Caius, *J. Bombay nat. Hist. Soc.*, 1939–40, **41,** 846).

*H. vulgatum* (Fr.) Almq. and *H. umbellatum* Linn. are herbs found from Kashmir to Garhwal at altitudes of 5,000–10,000 ft. The former species contains inulin. *H. umbellatum* contains phytosterol (Wehmer, II, 1269).

Some species of *Hieracium* are grown for ornament. The plants are propagated by divisions or by seed (Chittenden, II, 996).

## HIEROCHLOE Gmel. ex R.Br. (*Gramineae*)

D.E.P., III, 435; Fl. Br. Ind., VII, 222.

A small genus of perennial, erect, slender, sweet-scented grasses, found in temperate and cold regions of the world. About 6 species are found in India. *H. laxa* R.Br., a perennial grass, with stems 1–2 ft. high and stout creeping root-stock, is found in western Himalayas from Kashmir to Kumaon, at elevations of 10,000–16,000 ft. It bears small panicles of bronze or purple coloured spikelets and emits during drying a perfume like that of the sweet scented grass, *Anthoxanthum odoratum* Linn. *H. odorata* (Linn.) Beauv. syn. *H. borealis* Roem. & Schult. (SWEET GRASS, HOLY GRASS, VANILLA GRASS), a common grass in northern Asia, northern Europe and northern America, has a similar scent; it is used in N. America

for making mats, baskets and boxes, which remain scented for years. It is also reported to be used in the liqueur industry and fumigating powders. Its rhizome contains a coumarin. The ash (8.41%) of the plant contains: $SiO_2$, 42.73; $K_2O$, 37; Cl, 4.49; and $P_2O_5$, 7.42% (Stewart, *Brittonia, N.Y.*, 1945, **5**, 447: Hill, 45: Steinmetz, I, 234: Wehmer, I, 79).

*H. horsfieldii* Maxim., a species occurring in Java, provides cattle fodder. Analysis of the grass gave the following values: protein, 5.26; fat, 0.87; ash, 12.96; starchy substances, 45.93; and raw fibre, 34.98% (Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 201).

**Hill Mango** — *see* **Commiphora**

**Hilsa** — *see* **Fish & Fisheries**

**Himalayan Bear** — *see* **Sloth Bear & other Bears**

**Himalayan Cypress** — *see* **Cupressus**

**Himalayan Desert Candle** — *see* **Eremurus**

**Himalayan Marmot** — *see* **Fur & Fur-bearing Animals**

**Himalayan Pencil Cedar** — *see* **Juniperus**

**Hing** — *see* **Ferula**

**HIPPEASTRUM** Herb. (*Amaryllidaceae*)

Chittenden, II, 998; Bailey, 1949, 257.

A genus of showy bulbous herbs native of tropical America, now placed under *Amaryllis*. A few species and hybrids are cultivated in Indian gardens.

Some of the species and their numerous hybrids bear beautiful flowers of rich deep crimson, blood-red, orange-scarlet, white and pink colour. Several types with striped, mottled and blended corollas have also been evolved. Propagation is done by seeds or offsets. They may be grown in large pots, but do better in beds. Removal to a fresh situation every two or three years is beneficial (Firminger, 331).

**H. equestre* Herb. = *Amaryllis belladonna* Linn. is a lily-like plant with globose bulbs, strap-shaped leaves and a few fragrant, attractive, funnel-shaped flowers borne on erect stems 1–2 ft. high. The bulbs are used in Java for poulticing swellings of the neck and contusions. They are acrid and poisonous and contain 0.9% of an alkaloid, bellamarin, which is

FIG. 59. HIPPEASTRUM VITTATUM—IN FLOWER

identical with lycorine [$C_{16}H_{17}O_4N$: m.p., 275° (decomp.); $[\alpha]_D^{26°}$, −129°] (Burkill, I, 1176: Wehmer, I, 165: Henry, 406).

*H. vittatum* Herb. = *Amaryllis vittata* Ait. is another species cultivated in Indian gardens for its red and white striped flowers, 4–6 in. long and nearly as broad. The bulbs on injury exude a red pigment, which is classed with haematoxylin, brasilin, etc. (*Chem. Abstr.*, 1911, **5**, 3091).

**Hippocratea** — *see* **Pristimera**

**HIPPOMANE** Linn. (*Euphorbiaceae*)

Cooke, II, 627.

A genus of trees distributed in tropical America, West Indies and South Florida.

*H. mancinella* Linn. is a medium-sized laticiferous tree with ovate-elliptic leaves and inconspicuous flowers, grown in some of the Indian gardens for its attractive yellowish green fruit.

The milky latex is highly poisonous and irritant and acts as a vesicant when applied to the skin: it causes blindness for some days if it gets into the eyes. The smoke from the wood is also injurious to the eyes. In a dose of 20 drops, the latex causes fatal gastro-enteritis. In smaller doses (2 drops), however, it acts as a powerful cathartic and is administered

*There is considerable difference of opinion about the nomenclature and identity of this American plant. Some authors consider it to be different from the Linnaean species *Amaryllis belladonna*, which according to them was based on a cultivated Cape plant, popularly known as Cape Belladonna (Sealy, *Kew Bull.*, 1939, 49; Bailey, 1949, 257, 251; Chittenden, I, 96; II, 998).

as a vermifuge for children in Guiana, and against tetanus infection in Cuba. The latex also possesses diuretic properties (Caius, *J. Bombay nat. Hist. Soc.*, 1938–39, **40,** 293 ; U.S.D., 1947, 1514).

The wood is yellowish brown with black and brown markings, heavy (sp. gr., 0.60–0.68 ; wt., 38–43 lb./cu. ft.), lustrous, fine- and uniform-textured. It is durable, easy to work and finishes to a smooth surface. (Record & Hess, 160).

The tree is useful as a windbreak in coastal regions. The bark yields a resin (Williams & Williams, 188 ; Wehmer, II, 689).

**HIPPOPHAE** Linn. (*Elaeagnaceae*)

A small genus of shrubs and trees native of temperate regions of the Old World. Two species occur in India.

**H. rhamnoides** Linn. COMMON SEABUCKTHORN

D.E.P., IV, 251 ; Fl. Br. Ind., V, 203 ; Kirt. & Basu, Pl. 838A.

PUNJAB –*Neichak, kalabisa, sirma, tserkar* ; LADAKH & LAHOUL—*Sirma, tasru* ; U.P.—*Dhurchuk, chuma, tarwa*.

A dioecious, usually spinescent shrub or a small tree up to 40 ft. high, with rough brown bark, occurring in the river beds of the drier ranges of the north-western Himalayas at altitudes of 7,000–12,000 ft. Leaves small, linear-lanceolate, covered on both sides with silvery scales : flowers very small, greenish or yellowish, appearing with new leaves: male in axillary clusters, female solitary ; fruits enclosed by succulent receptacle, ovoid, *c.* 0.25 in. long, orange-yellow or scarlet : seeds oblong, testa crustaceous, shiny.

The fruit is acidic and is made into a jelly with sugar. A syrup prepared from it is used in lung complaints ; a decoction is used for cutaneous eruptions (Kirt. & Basu, III, 2177).

The fruit is a rich source of vitamin C (ascorbic acid, 135–608 ; dehydroascorbic acid, 30 mg./100 g.). Fairly stable food products with high vitamin C potency (juice, 1,000 ; juice powder, 10,000 ; and marmalade, 1,250 mg. vitamin C/100 g.) have been prepared from the fruit. The juice powder keeps its vitamin potency for 2½ years (*Chem. Abstr.*, 1945, **39,** 2585 ; 1949, **43,** 5510 ; *Hort. Abstr.*, 1949, **19,** 320).

The mature fruit is rich in carotene (6–8 mg./100 g. almost half that of carrots) ; it also contains vitamin $B_1$. The carotenoid pigments present in the fruit are: $\beta$-carotene, cryptoxanthin, zeaxanthin and its dipalmitic ester physalien, lycopene and $\gamma$-carotene. An anthocyanin identical with peonin (from *Paeonia* sp.) and a flavonol, *iso*-rhamnetin, are also present. The fruit contains malic acid, citric acid, tartaric acid, traces of succinic acid, reducing sugars, pectins, tannins and mannitol (*Chem. Abstr.*, 1950, **44,** 11032, 617 ; 1949, **43,** 3143 ; Wehmer, II, 815).

The fruit contains a dark red fatty oil (*c.* 2%) of pleasant odour and taste with the following characteristics: *d*, 0.9243 ; *n*, 1.4642 ; acid val., 7.35 ; sap. val., 190 ; iod. val., 76.5 ; solid. pt, 6.4° ; R.M. val., 0.79 ; acetyl val., 16.4 ; and unsapon. matter, 3.66%. The component fatty acids are: palmitic and stearic, 10.4 ; oleic, 63.4 ; and linoleic, 10.5%. The centrifuged oil is a concentrated source of carotene (164 mg./100 g.) (*Chem. Abstr.*, 1930, **24,** 4413 ; 1950, **44,** 11032).

The seeds contain (12.13%) a yellow, slow-drying oil with the following constants: *d*, 0.9278 ; *n*, 1.4739 ; acid val., 4.4 ; sap. val., 192.5 ; acetyl val., 10.4 ; iod. val., 138.2 ; and unsapon. matter, 1.78%. The component fatty acids are: palmitic and stearic, 10.9 ; oleic, 41.47 ; linoleic, 12.31 ; *iso*linoleic, 20.69 ; and linolenic, 14.63%. The pigments present in the seeds are zeaxanthin and carotene (*Chem. Abstr.*, 1930, **24,** 4413 ; 1950, **44,** 11032 ; Karrer & Jucker, 75).

The bark contains (3.06%) a yellow fatty oil with the following characteristics: *n*, 1.4639 ; acid val., 9.60 ; sap. val., 189.2 ; iod. val. (Margosches), 56.3 ; and solid. pt, 12.0°. The component acids are: palmitic and stearic, 37.4 ; and oleic, 62.6%. Two alkaloids in an impure state have been isolated from the bark. Carotene is also present (*Chem. Abstr.*, 1930, **24,** 4413 ; 1951, **45,** 8090 ; Henry, 773).

The twigs and leaves contain 4–5% tannin. The leaves contain carotene, ascorbic acid (340.8 mg./100 g.) and some dehydroascorbic acid. Presence of hemin (0.03 mg./100 g.) is reported in the root nodules (Wehmer, loc. cit. ; *Chem. Abstr.*, 1951, **45,** 8090 ; 1953, **47,** 12538 ; 1952, **46,** 11335).

The wood (wt., 38–54 lb./cu. ft.) is yellowish brown, mottled, hard and close-grained. It is used as fuel and for making charcoal.

*H. salicifolia* D. Don is a willow-like shrub occurring almost throughout the temperate Himalayas. It is allied to *H. rhamnoides* and has the same uses. Propagation is by seed or by layering. Both species are grown in many parts of the world as hedge plants (Chittenden, II, 1002).

**HIPTAGE** Gaertn. (*Malpighiaceae*)

A genus of climbing or sub-erect shrubs, rarely trees, distributed in tropical and subtropical parts of Asia. Three species occur in India.

**H. benghalensis** Kurz syn. *H. madablota* Gaertn.

D.E.P., IV, 252 ; III, 414, 429 ; Fl. Br. Ind., I, 418.

SANS.—*Madhavi, atimukta* ; HINDI—*Madhavilata, madhmalti, madho lata, kampti, aneta* ; BENG.—*Madhavi lata, madubh lata, madhubi, bosanti* ; MAR.—*Madhavi, haladvel* ; GUJ.—*Madhavi, rakatpiti* ; TEL.—*Madhavi-tige, vadlayerala, atimutamu* ; TAM.—*Madavi, vasandagalamalligai* ; KAN.—*Madhavi, vasantaduti* ; MAL.—*Sitampu* ; ORIYA—*Boromali, gorunda*.

PUNJAB—*Chopar, endra* ; KUMAON—*Aneta, banda ajari* ; NEPAL—*Madhabilata, charpate lahara* ; LEPCHA—*Tungchirrik* ; ASSAM—*Kerek-lata* ; BIHAR—*Gumdaba, gurundanari*.

A large, handsome, evergreen climbing shrub found throughout India and Andaman Islands, chiefly in damp places, ascending up to an altitude of 6,000 ft. Bark brown, exfoliating in flakes ; leaves opposite, 4–6 in. long, elliptic-oblong or ovate-lanceolate ; flowers fragrant, silky, in racemes : petals fringed, white, uppermost yellowish ; fruit of 1–3 unequally winged samaras ; seeds subglobose.

FIG. 60. HIPTAGE BENGHALENSIS—FRUITING BRANCH

The plant is cultivated in gardens for its attractive flowers. It is easily propagated by seed or by layering (Nairne, 41 ; Gopalaswamiengar, 356).

The leaves are used in cutaneous diseases. The leaf juice possesses insecticidal properties and is used as an application for scabies. The plant is also used in chronic rheumatism and asthma. The leaves are reported to be used as fodder (Kirt. & Basu, I, 417 ; Bressers, 22 ; Rama Rao, 57).

The bark is an aromatic bitter. It contains a crystalline glucoside, hiptagin [$C_{10}H_{14}O_9N_2 . \frac{1}{2} H_2O$ ; m.p., 110° ; $[\alpha]_D$, 3.5°]. The bark also contains 8.5% tannin (Wehmer, II, 664 ; Thorpe, VI, 90).

The wood is reddish brown with darker patches in the centre, moderately heavy (wt., 35–38 lb./cu. ft.), soft to tolerably hard, and rough. It is used for tool handles and as fuel (Gamble, 118 ; Cameron, 45 ; Gupta, 86).

**Hirudinea** — *see* **Leeches**

**HITCHENIA** Wall. (*Zingiberaceae*)

A small genus of rhizomatous herbs, distributed in south-western and eastern India, Burma and Malaya Three species are recorded from India of which one has been tried as a source of arrowroot starch.

**H. caulina** (Grah.) Baker syn. *Curcuma caulina* Grah.
INDIAN ARROWROOT

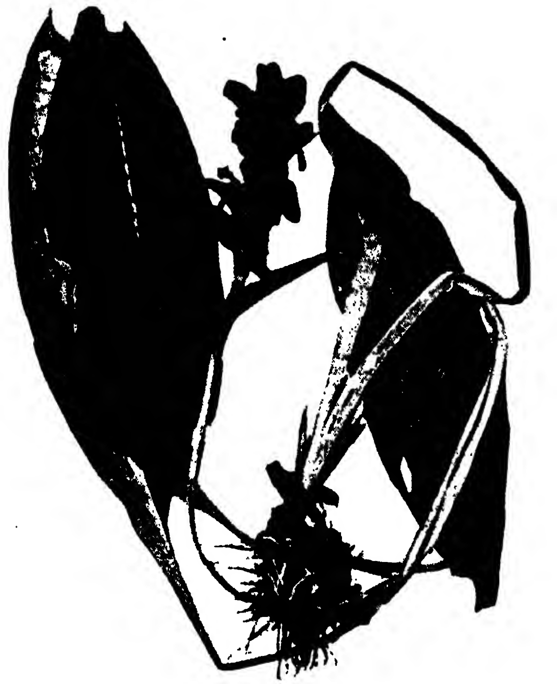
D.E.P., II, 658 ; C.P., 443 ; Fl. Br. Ind., VI, 224.

HINDI & BENG.—*Tikhur* ; MAR.—*Tavakhir*.

BOMBAY—*Chavara, chowar*.

An annual herb with ellipsoidal tubers, occurring wild on the tableland of Mahabaleshwar and a few other neighbouring areas in Bombay State and extending downwards on the west coast. Tubers of the size of an orange, sometimes larger, with white flesh inside ; stem leafy, 3–4 ft. high with oblong-lanceolate leaves, 12–20 in. long and 3–4 in. broad ; flowers yellow, borne on a central spike, which usually possesses a long peduncle.

The plant grows gregariously in open patches over an area of c. 16,000 acres on the Mahabaleshwar plateau ; in some places the growth is dense, as many as 20,500 plants per acre having been enumerated. The plant is easily propagated by tuber cuttings planted in raked soil at the beginning of the monsoon ; even thick peelings with eyes sprout readily. Shady ground in arecanut plantations and banks of



*Blatter Herbarium, Bombay*

FIG. 61. HITCHENIA CAULINA—FLOWERING PLANT

irrigation channels afford congenial situations for planting.

The tubers are rich in starch (10.9–18.3% on fresh weight) and constitute a valuable raw material for starch manufacture. Fully developed tubers contain a higher concentration of starch than immature ones; the starch content is higher in tubers harvested during February–March than in those harvested during the monsoon period. For ensuring high starch yields, only fully developed tubers should be harvested, necessitating a two-year rotation. The plant bears abundant foliage, and the possibility of utilizing the leaves for paper-making has been suggested (Information from the Chief Conservator of Forests, Bombay: Khairnar, *Indian For.*, 1945, **71**, 126; Turner, ibid., 1909, **35**, 449).

For the preparation of starch, harvested tubers are washed to remove adhering soil and fibrous roots are chopped off. Cleaned tubers are then grated, in hand operated wooden rollers and the grated material collected in a trough, through which water is continuously flowing. The starch is washed, sieved through cloth and washed again; the process of sieving and washing is repeated 3–4 times. The starch is then spread evenly on clean sheets and dried in the sun. An average yield of 13.6% (on fresh wt.) of starch, of which c. 8% is of superior quality has been reported. The product is devoid of taste or colour and is suitable for human consumption; it compares favourably with imported arrowroot starch (Table 1). An inferior product obtained by two washings is suitable for making adhesives and for sizing textile fibres (Khairnar, *Indian For.*, 1945, **71**, 126).

TABLE 1—ANALYSES OF ARROWROOT POWDERS FROM H. CAULINA & MARANTA ARUNDINACEA*

| | Indian arrowroot | West Indian arrowroot | |
|---|---|---|---|
| | | Sample A | Sample B |
| Moisture (%) | 10.40 | 12.90 | 11.90 |
| Ash (%) | 0.50 | 0.28 | 0.42 |
| Water solubles (%) | 0.14 | 0.41 | 0.19 |
| Ether solubles (%) | 0.10 | 0.70 | 0.64 |
| Starch (%) | 88.86 | 85.71 | 86.85 |
| Viscosity at 25° (sec.) | 18 | 21 | 17 |
| Acidity: N. alkali required for 100 g. starch (cc.) | 1.342 | 0.732 | 1.830 |

* Khairnar, *Indian For.*, 1945, **71**, 126.

The tubers have been occasionally utilized for the manufacture of starch. During World War II, when arrowroot starch was scarce or unavailable, the Forest Department, Bombay, leased out *H. caulina* areas to a few firms for the manufacture of starch (Information from the Chief Conservator of Forests, Bombay).

**HODGSONIA** Hook. f. & Thoms. (*Cucurbitaceae*) Fl. Br. Ind., II, 606.

A small genus of two species of large woody climbers, distributed from north-eastern India to Malaysia. *H. heteroclita* Hook. f. & Thoms.* (Beng.—*Gulur*; Nepal—*Darsani, ghinphal*; Assam—*Thebou-lata, tapouguti*; Lepcha—*Kathior-pat*; Lushai—*Kha-um*; Abor—*Thekrai*; Lakhimpur—

* Kundu (*J. Bombay nat. Hist. Soc.*, 1942–43, **43**, 362) considered the two species of the genus as quite distinct, but erroneously applied the name *H. macrocarpa* to the Indian plant. *H. macrocarpa* is based on a type collected from Borneo (Indonesia) under the name *Trichosanthes macrocarpa* Blume, and is, therefore, more appropriate for the Malaysian plant.

*Astepa*) occurs in Sikkim, North Bengal and Assam up to an altitude of 5,000 ft. It differs from the Malaysian species, *H. macrocarpa* (Blume) Cogn. syn. *H. capniocarpa* Ridley in minor botanical features. According to some authors the two species may be treated under the name *H. macrocarpa* (Blume) Cogn. (Kundu, *J. Bombay nat. Hist. Soc.*, 1942–43, **43,** 362 ; Burkill, I, 1178).

The plants included under these species are large vigorous climbers, up to 100 ft. in length, bearing large globose fruits, 4–10 in. diam., with hard, bitter, inedible flesh. Fruit contains 4–8, large (2–3 in. × 1.0–1.5 in.), flattish seeds. The raw seed kernel is bitter, but is esteemed as an edible nut after roasting or baking. The kernel (*c.* 33% of the whole seed) contains: protein, 21.5 ; and fatty oil, 66.5%. The fatty oil extracted from the kernel is non-drying and has the following characteristics: sp. gr.$^{30°}_{15.5}$, 0.907 ; $n^{30°}_{D}$, 1.4613 ; acid val., 3.6 ; sap. val., 201.2 ; iod. val., 67.1 ; and unsapon. matter, 0.4% ; titre, 42.1°. The fatty acid composition of the oil is as follows: myristic, 0.6 ; palmitic, 37.3 ; stearic, 8.7 ; arachidic, 0.8 ; oleic, 27.1 ; linoleic, 24.6 ; and hexadecenoic

FIG. 62. HODGSONIA HETEROCLITA—MALE FLOWERS

FIG. 63. HODGSONIA HETEROCLITA—FRUIT

acid, 0.9%. The concentration of saturated acids is notably higher than that found in any other cucurbitaceous seed. The oil is used as a substitute for coconut oil for cooking in Malaya ; it is used as a medicinal oil in Borneo (Fl. Assam, II, 326 ; Burkill, I, 1179; Wehmer, II, 1206 ; Georgi & Teik, *Malay. agric. J.*, 1929, **17,** 392 ; Jamieson, 251 ; Eckey, 770).

**Hog-deer** — *see* **Deer**

**Hog Gum** — *see* **Cochlospermum**

**Hog Plum** — *see* **Spondias**

**Hogs** — *see* **Livestock**

**Hog Tragacanth** — *see* **Prunus**

## HOLARRHENA R.Br. (*Apocynaceae*)

A genus of shrubs or trees found in the tropics and subtropics of the Old World. One species occurs in India.

**H. antidysenterica** (Linn.) Wall.

D.E.P., IV, 255 ; C.P., 640 ; Fl. Br. Ind., III, 644.

SANS.—*Kutaja, kalinga* ; HINDI—*Kurchi, karchi, karra, kora, kuar, kureya, kura* ; BENG.—*Kurchi* ; MAR.—*Kodaga, kuda, dola-kuda, pandhara-kuda* ; GUJ.—*Dhowda, kuda, kari* ; TEL.—*Pala, kodaga* ; TAM.—*Veppalei, kodagapalei, indrabam* ; KAN.—*Beppale, koodsaloo, korchie* ; MAL.—*Kodagapala* ; ORIYA—*Kherwa, pita korwa, patru kurwa.*

PUNJAB—*Keor, kewar* ; NEPAL—*Khuria* ; LEPCHA—*Fajeerip* ; BIHAR—*Dudhiari* ; ASSAM—*Dhutkhuri, dudkhuri.*

A deciduous laticiferous shrub or small tree 30–40 ft. high and up to 4 ft. in girth, with a clear

bole of 10–20 ft., occurring almost throughout India up to an altitude of 4,000 ft., often gregariously in deciduous forests and open waste lands; it is especially abundant in the sub-Himalayan tract. Bark rather rough, pale brownish or greyish, peeling off in irregular flakes: leaves opposite, subsessile, elliptic or ovate-oblong, 4–12 in. × 2–5 in., membranous: flowers white, in terminal corymbose cymes; follicles divaricate, cylindric, 6–18 in. long and 0.2–0.4 inch in diam., usually white spotted: seeds light brown, 0.3–0.5 in. long, 900–1,000 seeds weighing one oz., 25–30 in a follicle: coma brownish, spreading, 1–2 in. long.

The species is important in reclothing waste lands; it is one of the first to come up and is the last to disappear in denuded forests. It acts as a nurse to more valuable species, especially *sal* seedlings, in forests. It is also cultivated as an ornamental plant for its beautiful flowers which are borne in great profusion in spring before the appearance of leaves: a second flush is often produced in September–November.

FIG. 64. HOLARRHENA ANTIDYSENTERICA—FRUITING BRANCH

In its natural habitat, the maximum shade temperature varies from 105 to 118°F. and the minimum from 30 to 55°F.: the normal annual rainfall varies from 30 to 150 in. Though sensitive to frost, the tree recovers easily from damage. It can stand slight shade, but develops best in full light, and is drought-hardy. The plant coppices well and shoots up readily after severe scorching by fire; it produces root-suckers in abundance.

Natural reproduction is abundant owing to regular and copious seeding from an early age, comparative immunity of the plant from damage by animals and its power of recovery from injury of all kinds. Seeds germinate during the early rains and seedlings attain a height of 4–6 in. by the end of the first year. Weeding and watering stimulate growth. In subsequent years growth is more rapid, the mean annual girth increment being 0.78–0.9 in.

Artificial reproduction can be secured both by direct sowing and by transplanting. Fresh seeds have a high percentage of germination but in seeds more than a year old the viability is low. The species is successfully grown by line sowing with field crops. Weeding, periodic thinning, and loosening of soil at intervals are beneficial (Troup, II, 664–68).

The stem and root barks are medicinal and have long been used in India in the treatment of dysentery. Under the name of KURCHI (HOLARRHENA, CONESSI BARK, TELLICHERRY BARK), the stem bark is official in I.P. It consists of dried bark collected from 8–12 year old plants and freed from attached wood; it is available in small pieces, curved or quilled, 1–6 cm. long, 1–4 cm. broad and 1–7 mm. thick: outer surface greyish brown to reddish brown, longitudinally wrinkled with occasional transverse and longitudinal cracks, frequently covered with grey lichens showing small black apothecia: thicker pieces rugose and showing numerous yellowish warts; inner surface cinnamon-brown, longitudinally striated, frequently with portions of pale yellow wood attached; fracture brittle; odour faint; taste bitter. According to I.P., kurchi should contain $\nless 2\%$ total alkaloids, $\ngtr 1\%$ acid-insoluble ash and $\ngtr 5\%$ foreign organic matter. It should be stored in dry, well closed containers. The root bark is similar to stem bark, but of a deeper and more rusty colour (I.P.C., 135; B.P.C., 1949, 402; Dymock, Warden & Hooper, II, 394; I.P., 358).

The bark has astringent, antidysenteric, anthelmintic, stomachic, febrifugal and tonic properties. It is used in the treatment of amoebic dysentery and

*F.R.I., Dehra Dun* *Photo: T. B. Chitrakar*

HOLARRHENA ANTIDYSENTERICA

diarrhoea, and is usually administered as extract or decoction. Although slow in action as compared with emetine, it is less toxic and can be administered orally. Kurchi bark is given either alone or with other astringent drugs in piles, colic, dyspepsia, chest affections and diuresis; it is also used for diseases of the skin and spleen. A hot decoction of the drug is used as a gargle in toothache. A powder prepared from the bark is rubbed on the body by Santals in dropsy (Kirt. & Basu, II, 1570; Benthall, 310; B.P.C., 1949, 403; Koman, 1918, 3; Chopra, 327; Dymock, Warden & Hooper, II, 393; Das Gupta, *Sci. & Cult.*, 1951–52, **17,** 421).

The therapeutic value of kurchi is due to the presence of alkaloids which occur as tannates. The total alkaloid content of Indian kurchi is 0.22–4.2% (av. 2.2%). It varies with the age of the plant, reaching the maximum in 8–12 years old plants. It also varies with the season; the maximum alkaloid content has been reported from bark collected soon after the rains (July-September). The average total alkaloid contents in other parts of the plant are: stem, 0.52; leaves, 0.97; flowers, 0.55; and seeds, 1.825% (Dutta & Ghosh, *Indian J. Pharm.*, 1949, **11,** 74; Prasad & Kaul, ibid., 1957, **19,** 131; Dutta *et al.*, *Indian J. med. Res.*, 1950, **38,** 467; Siddiqui *et al.*, *J. sci. industr. Res.*, 1944–45, **3,** 555).

The principal alkaloid of kurchi is conessine (yield, 0.4%), a stenol with a structure resembling 7-ergosten-3-ol and Y-stigmastenol. Seventeen other alkaloids besides conessine (Table 1) have been isolated and described, but the identity of some of them is still doubtful (Henry, 742–48; *Chem. Abstr.*, 1951, **45,** 1608; Siddiqui & Pillay, *J. Indian chem. Soc.*, 1932, **9,** 553).

Clinical and laboratory trials have shown that conessine and related alkaloids possess amoebicidal properties comparable to emetine. *Entamoeba histolytica* in mucus flakes is killed by emetine in a dilution of 1 in 200,000 and by conessine, in a dilution of 1 in 280,000. Conessine hydrobromide ($C_{24}H_{40}N_2 \cdot 2HBr$) is official in International Pharmacopoeia; it contains $\nless$67.5 and $\ngtr$69.0% conessine. It is prescribed in amoebic dysentery and is considered to be less toxic than the base. It has the advantage over emetine hydrochloride of oral efficacy, but sometimes causes neuropsychiatric manifestations. It produces, particularly with doses of more than 500 mg. daily, restlessness, tremors, insomnia, vertigo and gastro-intestinal disturbances. Calcium gluconate and barbiturate minimise the toxic effects. A glycerine suppository containing conessine hydrobromide has been successfully used in trichomoniasis. Kurchin Bismuth Iodide, a combination of the total alkaloids of kurchi and bismuth iodide is official in I.P. It should contain $\nless$23 and $\ngtr$27% of kurchi alkaloids and $\nless$18 and $\ngtr$24% of bismuth (Chopra, 328–38; U.S.D., 1955, 360; Int. P., II, 81; I.P., 359).

TABLE 1—KURCHI ALKALOIDS*

| Alkaloids | Formula | m.p. (°C.) |
|---|---|---|
| Conessine | $C_{24}H_{40}N_2$ | 125 |
| *nor*-Conessine | $C_{23}H_{38}N_2$ | † |
| Conessimine | $C_{23}H_{38}N_2$ | 100 |
| *iso*-Conessimine | $C_{23}H_{38}N_2$ | 92 |
| Kurchine | $C_{23}H_{38}N_2$ | 75 |
| Conimine | $C_{22}H_{36}N_2$ | 133–35.5 |
| Conamine | $C_{22}H_{36}N_2$ | 130<br>97.5–101.5 |
| Conarrhimine | $C_{21}H_{34}N_2$ | .. |
| Conkurchine | $C_{21}H_{32}N_2$ | 152–53 |
| Concessidine | $C_{22}H_{34}N_2$ | 123–25 |
| Trimethyl conkurchine | $C_{24}H_{38}N_2$ | 125–28 |
| Holarrhimine | $C_{21}H_{36}N_2O$ | 183 |
| Holarrhenine | $C_{24}H_{38}N_2O$ | 197–98 |
| Holarrhine | $C_{20}H_{38}N_2O_3$ | 240 |
| Holarrhessimine | $C_{22}H_{36}N_2O$ | 160–64 |
| Lettocine | $C_{17}H_{25}NO_2$ | 350–52 |
| Conkurchinine | $C_{25}H_{36}N_2$ | 161 |
| Kurchicine | $C_{20}H_{36}N_2O$ | 175 |

* Roy & Mukerji, *J. sci. industr. Res.*, 1958, **17A,** 158. † Oil: b.p., 238–40°/0.7 mm.

Conessine possesses antitubercular activity *in situ*. It increases coronary outflow in the isolated rabbit heart, induces narcosis in frog, and produces local anaesthesia in guinea pigs, being twice as active as cocaine, but causes necrosis on subcutaneous injection (Henry, 748; Burger, II, 859; *J. Pharm., Lond.*, 1949, **1,** 340).

In addition to the alkaloids, kurchi contains: gum, 9.56; resin, 0.2; and tannin, 1.14%. A triterpene alcohol, lupeol ($C_{31}H_{50}O$; m.p., 213–14°) and $\beta$-sitosterol have been isolated from the unsaponifiable matter of the bark. Kurchi gum is rust brown in colour, bitter in taste and has the following constants: sp. gr.$^{31°}$, 1.092; $[\alpha]_D$, *nil;* acid val., 65.28; ester val., 106.14; sap. val., 171.42; and acetyl val., 250.52. It is reported to be effective in some cases of dysentery. An aqueous solution of the gum (1 : 400)

kills *Paramoecium* in two hours (Caius & Mhaskar, *Indian med. Res. Mem.*, No. 6, 1927, 1 ; Siddiqui & Pillay, *J. Indian chem. Soc.*, 1933, **10,** 673 ; Ganguly & Bagchi, *J. Instn Chem. India*, 1953, **25,** 46).

The seeds (HINDI—*Karwa-indarjau* ; BENG.—*Tita-indarijau* ; MAR.—*Kadu-indarjau* ; GUJ.—*Kadvo-indarjau;* TEL.—*Amkudu-vittulu;* TAM.—*Kulappallai-virai* ; KAN.—*Kodu-murakan-bija*) are considered to possess similar properties as the bark and are put to similar uses. They are also used in pessaries for promoting conceptions, for toning up vaginal tissues after delivery and for veterinary purposes. The seeds contain many of the alkaloids present in the bark but in a lower concentration (1.82). A glyco-alkaloid [m.p., 200° (decomp.)] has also been isolated. Hydrolysis of the glyco-alkaloid with picric acid yields conessine picrate, a second picrate (m.p., 113–16°), and galactose. Small amounts of tannin and resin are also present in the seeds. A decoction (1 : 150) of the seeds kills *Paramoecium* within 15 minutes (Dastur, Medicinal Plants, 136 ; Chopra, 332 ; Rama Rao, 254 ; Irani, *Curr. Sci.*, 1946, **15,** 229 ; Caius & Mhaskar, loc. cit.).

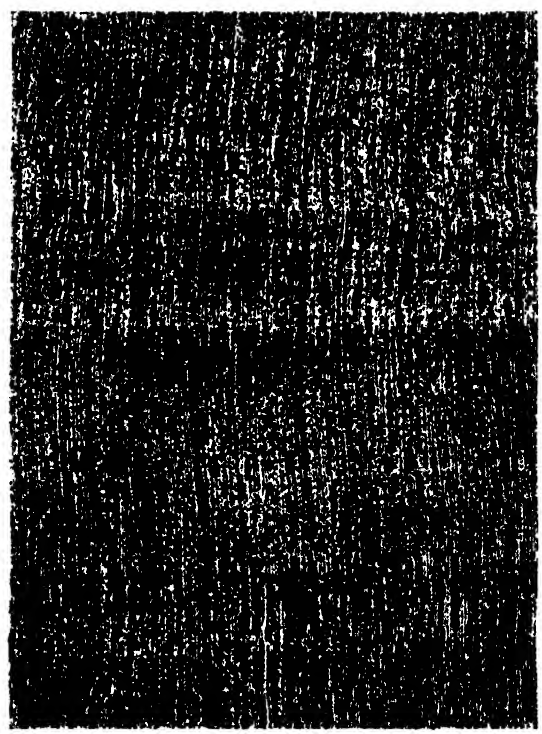
The seeds yield 19–30% of a greenish yellow drying oil, with penetrating odour and mild taste, and the following constants: sp. gr.$^{15°}_{15°}$, 0.9354 ; $n_D^{60°}$, 1.4666 ; acid val., 36.1 ; sap. val., 180.5 ; iod. val., 149.1 ; acetyl val., 22.9 ; R.M. val., 1.7 ; Pol. val., 0.4 ; Hehner val., 94.3 ; and unsapon. matter, 3.5%. The component fatty acids of the oil are: linolenic, 10 ; linoleic, 54.7 ; oleic, 21 ; palmitic, 5.6 ; stearic, 6.8 ; and lignoceric, 1.9%. The unsaponifiable matter contains 17.4% phytosterol. The oil has been used as an anthelmintic [Krishna *et al.*, *Indian For. Rec.*, *N.S.*, 1936, **1**(1), 1 ; Ghanekar & Ayyar, *J. Indian Inst. Sci.*, 1927, **10A,** 24].

The leaves are used in chronic bronchitis, and for boils and ulcers. In Bihar, the roots and leaves are used in dysentery. A powder prepared from the roots and leaves is administered to stop haemorrhages after child birth and bleeding from the nose. A dye similar to indigo is extracted from the leaves. The flowers are eaten and also employed in blood diseases. The floss from the seeds is used for stuffing pillows (Benthall, 310 ; Bressers, 90 ; Chopra, 327).

The latex from the plant contains: water and water-solubles, 57.0–91.1 ; and caoutchouc, 1.5–9.7%. The coagulum contains: caoutchouc, 15.0–22.8 ; resins, 74.1–82.8 ; and insolubles, 0.9–5.9%. Two resinols, lettoresinol-A ($C_{28}H_{50}O_3$ ; m.p., 227–28°) and lettoresinol-B ($C_{32}H_{56}O_2$ ; m.p., 136–37°) have been isolated from the latex (Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 4 ; Chowdhury & Peacock, *J. chem. Soc.*, 1935, 1129).

The wood is white when first exposed, turning yellowish with age ; heartwood not distinct, lustrous, straight- and close-grained, fine- and even-textured, moderately soft and light (sp. gr., *c.* 0.55 ; wt., 35 lb./cu. ft.). The timber seasons well without much difficulty and develops few end-splits and surface-cracks with little tendency to warping, but is liable to damage by insects. Air seasoning in the log reduces surface cracking and kiln seasoning improves the colour of the timber and reduces liability to insect attack. The wood is fairly durable under cover and easy to saw and machine. It is a high class turnery wood and is suitable for carving (Pearson & Brown, II, 728).

The wood is used for making small articles, such as combs, picture frames, carved boxes, toys, spoons, cups and platters, bobbins, bedstead legs, paper knives, walking sticks, *hookah* stems, ploughs, beads and sometimes for furniture. It is a first class timber for slate frames. It is also suitable for pen holders,



*F.R.I., Dehra Dun. Photo : K. N. Tandon*

**FIG. 65. HOLARRHENA ANTIDYSENTERICA—TRANSVERSE SECTION OF WOOD (× 10)**

mathematical instruments, brush backs, and spools and pirns for silk textiles. It has been recommended for cotton reels, shoe heels, and engraving and printing blocks (Pearson & Brown, II, 728; Trotter, 1944, 199, 209; Rehman *et al.*, *Indian For. Leafl.*, No. 138, 1954, 3).

The ash from the wood is rich in potash. It contains: total solubles, 17.5; $K_2CO_3$, 10.82; KCl, 4.2; $K_2SO_4$, 2.48; and insolubles, 80.74%. The wood ash is reported to be used in Chota Nagpur for dyeing purposes and as a caustic to open abscesses (Mata Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 16; Benthall, 310; Rama Rao, 254).

**HOLBOELLIA** Wall. (*Lardizabalaceae*)

D.E.P., IV, 259; Fl. Br. Ind., I, 108.

A small genus of evergreen twining shrubs distributed in China and the Himalayas. One species, *H. latifolia* Wall. (Nepal—*Bagul*; Kumaon—*Gophla, gophal*; Khasi—*Soh-lygn-kait, mi-rang-k'sa*), occurs in the Himalayas, from Kumaon eastwards to Sikkim, Bhutan, Assam, Khasi and Jaintia hills and Manipur, at an elevation of 4,000–9,000 ft. It is a vigorous climber, with palmately divided leaves and monoecious flowers borne in axillary racemes. The flowers are green or greenish purple and sweet scented. The fruits are large, 2–4 in. long, rosy purple, containing many hard, black seeds embedded in an edible pulp. The pulp is considered by some as mealy and insipid (Fl. Assam, I, 61; Kingdon-Ward, 56; Gamble, 28).

This climber is well worth growing on a pergola for its ornamental foliage. It can be easily propagated by seeds (Kingdon-Ward, 57).

**HOLCUS** Linn. (*Gramineae*)

Fl. Br. Ind., VII, 724.

A small genus of annual or perennial grasses found in Europe, Africa and temperate Asia. One species, *H. lanatus* Linn. (Yorkshire Fog, Velvet Grass), a perennial, soft, tomentose, tufted grass, 60–90 cm. high, indigenous to Europe and temperate Asia, has become naturalised in India and is found in Sikkim and Darjeeling, up to about 7,000 ft. and in Shillong in Assam. The culms are 3–4 noded and bear leaves 15–25 cm. long with the sheaths of upper leaves inflated (Fl. Assam, V, 134).

Yorkshire fog is considered a weed, but sometimes grown for hay or forage. Analysis of the grass cut in spring gave the following values (dry basis): crude protein, 12.5; ether extr., 4.71; crude fibre, 16.4; ash, 11.9; Ca, 0.57; and P, 0.22%; copper (5.7 p.p.m.) and iodine (390 $\mu$g./kg.) are also present. The grass contains a cyanogenetic glycoside. Occasionally it produces prussic acid in sufficient amount to cause poisoning when eaten (Muenscher, 37; Coop *et al.*, *N. Z. J. Sci. Tech.*, 1952–53, **34A**, 507; Iodine Content of Foods, 114; Wehmer, I, 78).

**HOLIGARNA** Buch.-Ham. (*Anacardiaceae*)

A small genus of trees distributed in the Indo-Malayan region. Seven species occur in India. Most of the species yield a black, vesicant, resinous juice.

**H. arnottiana** Hook. f.

D.E.P., IV, 259; Fl. Br. Ind., II, 36; Kirt. & Basu, Pl. 280.

Mar.—*Holgeri, bibu, sudrabilo*; Tam.—*Karun charei, kattucceram*; Kan. *Holigar, hoolgeri, holageru, katugeri*; Mal.—*Chera, charei, kattuchera.*

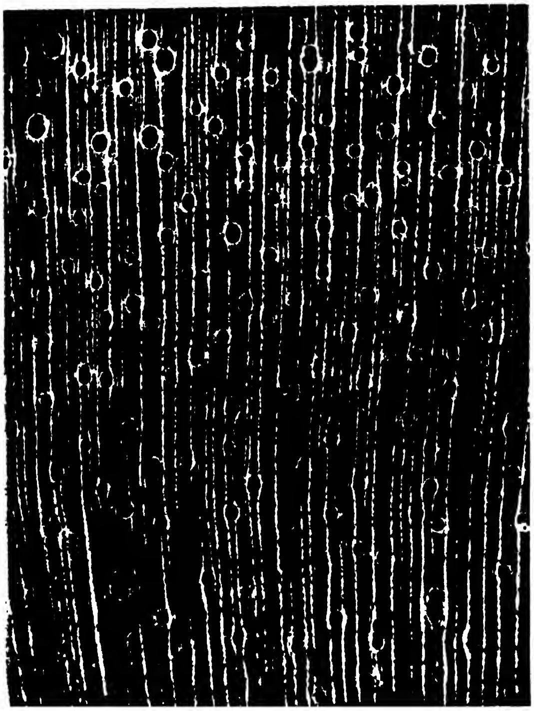
A tall deciduous tree often with a buttressed bole, up to 50 ft. in length and 9 ft. in girth, found in the western ghats from Konkan southwards. Leaves alternate, cuneate-obovate, 6–12 in. × 2–4 in., glabrous; flowers minute, polygamous or unisexual, in axillary and terminal panicles; fruit a drupe, *c.* 1 in. long, obliquely oblong.

The tree grows best on moist, deep fertile soil of evergreen forests. It prefers shade in the seedling stage but later becomes light loving. Natural reproduction takes place by seeds which germinate during the early part of the rainy season. The rate of growth is moderately fast (Kadambi, *Indian For.*, 1955, **81**, 103).

The wood is light grey, lustrous, straight-grained, coarse-textured, soft, light (sp. gr., 0.38; wt., 25 lb./cu. ft.), strong and elastic. It can be easily seasoned by green conversion and open stacking under cover. Salt water seasoning is also advocated. The wood is moderately durable under cover and in contact with water, but perishes in exposed situations. It is liable to develop sap stain unless properly seasoned and is readily attacked by insects and termites. It treats without difficulty with creosote. The timber saws and works with great ease (Kadambi, loc. cit.; Pearson & Brown, I, 342–44).

The timber is used for packing cases, cigar cases, boats, dugouts, bullock carts, match splints and match boxes. It is said to be good for second grade pencils (Pearson & Brown, I, 344; Kadambi, loc. cit.; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1954, 6).

All parts of the tree yield a black, resinous juice



*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 66. HOLIGARNA ARNOTTIANA—TRANSVERSE SECTION OF WOOD (× 10)

which is vesicant. The juice is used as a varnish and for waterproofing boats and furniture. It is also used for fixing indelible black patterns on linen and cotton cloth (Bourdillon, 110).

The leaves are used as green manure. The fruits are employed to bait flying foxes and porcupines. The fruit and the bark are reported to possess medicinal properties (Rama Rao, 101 ; Kirt. & Basu, I, 672).

**H. grahamii** Hook. f.

D.E.P., IV, 260: Fl. Br. Ind., II, 37.

MAR.—*Bipte, balwuli.*

BOMBAY—*Ran bibu ;* MYSORE—*Dodda-yele-holagara, kan-kanagalu.*

A medium-sized to large tree found in the western ghats and parts of Deccan. Bark smooth, thin ; leaves 12–16 in. long, oblanceolate, coriaceous, crowded at the ends of branches ; flowers small, unisexual, in terminal panicles ; drupe oblong-ovoid.

The wood is grey, with dark streaks, soft and light (wt., *c.* 30 lb./cu. ft.). It is said to be suitable for matches and packing cases (Naidu, 77).

The tree yields a black juice similar in properties to that obtained from *H. arnottiana* and is used as a varnish (Naidu, 77).

**H. longifolia** Roxb.

D.E.P., IV, 260 ; Fl. Br. Ind., II, 37.

CACHAR—*Bonsu-buphang;* LUSHAI HILLS—*Katebel;* MANIPUR—*Kherai.*

A tall, buttressed tree with spreading branches, found in the evergreen forests of Assam. Bark grey, smooth ; leaves 12–24 in. × 3–5.5 in., cuneiform-oblanceolate, acuminate, coriaceous, glabrous ; flowers small, unisexual or polygamous, in axillary panicles ; fruit a drupe, oblongish, slightly compressed, enclosed by calyx tube.

The juice obtained from the bark and the rind of the fruit is caustic and blisters the skin. It is also used as a varnish and for lacquer work (Badhwar *et al.*, *Indian J. agric. Sci.*, 1945, **15**, 155).

The wood is grey with yellowish streaks, soft and light (wt., 25 lb./cu. ft.). It is used for house building and for making boats. The fruit and the bark are reported to possess medicinal properties (Fl. Assam, I, 337 ; Kirt. & Basu, I, 672).

*H. nigra* Bourd. is a tree found in the evergreen forests of Travancore. Its juice may be used as a varnish. The wood is greyish white, soft, coarse and open-grained (Fl. Madras, 268).

**Hollandite** — *see* **Manganese Ores**

**Hollock** — *see* **Terminalia**

**Holly** — *see* **Ilex**

**Hollyhock** — *see* **Althaea**

**Hollyhock, Trailing** — *see* **Hibiscus**

**HOLMSKIOLDIA** Retz. (*Verbenaceae*)

D.E.P., IV, 260 ; Fl. Br. Ind., IV, 596.

A small genus of woody climbers distributed in Africa, Madagascar, India and Burma.

*H. sanguinea* Retz. (CHINESE-HAT-PLANT ; PARASOL FLOWER : HINDI—*Kapni ;* DEHRA DUN—*Rithoul ;* KUMAON—*Kultolia ;* NEPAL—*Sarpattia ;* LEPCHA—*Sivettachin ;* ASSAM—*Manu-kata-phul, mei-da-kyna, misi-nasil*) is a large climbing or scrambling shrub with drooping branches and opposite ovate-elliptic leaves, found in the Himalayas from the Sutlej eastwards ascending up to an altitude of 5,000 ft., Assam and parts of Bihar. It is commonly cultivated in gardens throughout India for its axillary or terminal cymes of showy scarlet flowers with obconic, campanulate, petaloid, persistent calyx. The plant can be grown with little care and does best in full sunshine. It is propagated by layers, cuttings or seeds and

*F.R.I., Dehra Dun. Photo : M. B. Raizada*

FIG. 67. HOLMSKIOLDIA SANGUINEA—FLOWERING BRANCH

should be closely pruned after flowering. The plant is eaten by sheep and goats. The wood (wt., 43 lb./cu. ft.) is light red and moderately hard (Bor & Raizada, 143 ; Gamble, 544).

## HOLOPTELEA Planch. (*Ulmaceae*)

A small genus of trees distributed in tropical and sub-tropical parts of Asia and Africa. One species occurs in India.

### H. integrifolia Planch.

D.E.P., IV, 261 ; III, 414 ; Fl. Br. Ind., V, 481 ; Kirt. & Basu, Pl. 885.

SANS.—*Chirabilva* ; HINDI—*Kanju, papri, banchilla, chilbil, dhamna, begana* ; MAR.—*Vavli, papara* ; GUJ.—*Kanjho, waola* ; TEL.—*Thapasi, nemali, peda-nevili* ; TAM.—*Aya, ayil, kanci, vellaya* ; KAN.—*Thavasai, rasbija, kaladri, nilavahi* ; MAL.—*Aval* ; ORIYA—*Dauranja, turuda.*

PUNJAB—*Rajain, khulen, arjan* ; KUMAON—*Papar, kanju* ; M.P.—*Karanji, chirhol, karanjalam.*

TRADE—*Kanju, Indian Elm.*

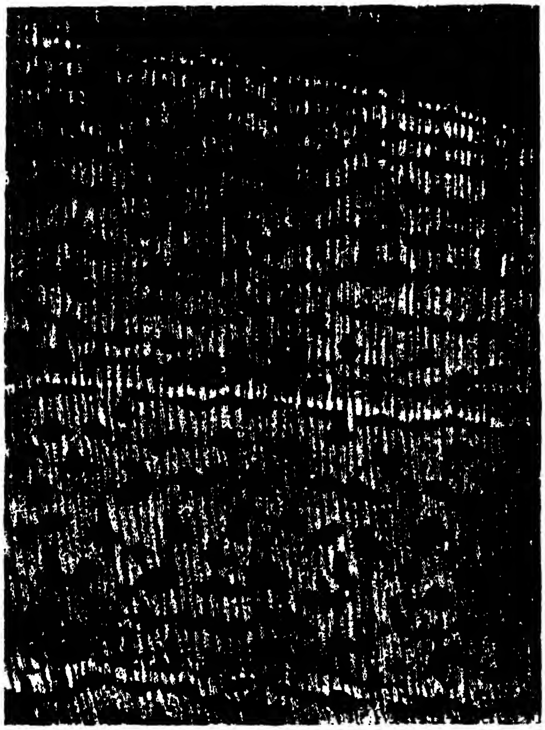
A large deciduous tree distributed throughout the greater part of India up to an altitude of 2,000 ft. It is sometimes grown on the road side. Bark grey, pustular, exfoliating in somewhat corky scales ; leaves elliptic-ovate, acuminate, base rounded or subcordate ; flowers greenish yellow, polygamous, in short racemes or fascicles ; fruit a sub-orbicular samara with membranous wing, edible ; seed flat. The bark when cut and the leaves and twigs when crushed emit an unpleasant odour.

*H. integrifolia* thrives in deep porous soil with good drainage but becomes stunted and crooked on poor shallow soil. It is a moderate light demander and is not frost-hardy. It coppices well. The tree sheds its seeds during the hot season and they germinate at the commencement of the rains. Protection from sun in early stages is beneficial. The rate of growth is fast, the mean annual girth increment being 1.05 in. (Troup, III, 855–59).

The wood is light yellow with an unpleasant odour

*F.R.I., Dehra Dun. Photo : H. G. Champion*

FIG. 68. HOLOPTELEA INTEGRIFOLIA



*F.R.I., Dehra Dun. Photo: K. A. Chowdhury*

FIG 69 HOLOPTELEA INTEGRIFOLIA—TRANSVERSE SECTION OF WOOD (× 10)

when freshly cut, lustrous, somewhat interlocked-grained, medium- and even-textured, moderately heavy (sp. gr., *c.* 0.63; wt., 39-41 lb./cu. ft.) and strong. There is no distinct heartwood (Pearson & Brown, II, 903-05).

Kanju seasons well but is liable to stain and decay. Green conversion and open stacking give the best results. The wood can be kiln-seasoned successfully and retains its brightness and colour. Well seasoned wood is fairly durable in sheltered and well-ventilated locations; for use in exposed places the wood requires to be given a pressure antiseptic treatment. Kanju saws easily, machines well, takes a good polish and can be turned to a fair surface (Pearson & Brown, II, 906; Trotter, 1944, 117).

The data for the comparative suitability of timber, expressed as percentages of the same properties of teak, are: wt., 85; strength as a beam, 65; stiffness as a beam, 65; suitability as a post, 65; shock-resisting ability, 100; retention of shape, 80; shear, 95; and hardness, 80. It is a good fuelwood; the calorific value of sapwood is 5,258 cal., 9,464 B.t.u. [Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 18; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 18].

The wood on dry distillation at 375° gave the following products (dry basis): charcoal, 36.7; total distillate (dry), 41.4; pyroligneous acid, 38.5 (wet), 32.7 (dry); tar, 8.8; pitch and losses, 3.6; acid, 3.78; ester, 2.80; acetone, 1.90; methanol, 1.27%; and gas at N.T.P., 1.83 cu. ft./lb. (Kedare & Tendolkar, *J. sci. industr. Res.*, 1953, **12B**, 217).

Kanju timber is used for brush backs and handles of dusting brooms, for which it is very suitable. It is also used for indoor building purposes, cheap furniture, cabinet work, carving, ploughs, yokes, carts and carriages, combs, shoe heels, mathematical instruments, warper bobbins for jute mills, cotton reels, dugout boats and for making charcoal. The wood is suitable for plywood, packing cases and boxes, slate frames, multi-ply jute bobbins, match boxes and splints, and paper pulp (Pearson & Brown, II, 906; Trotter, 1944, 118, 199, 214; Rehman *et al.*, *Indian For.*, 1954, **80**, 626; Rama Rao, 376; Rehman & Askari, *Indian For.*, 1956, **82**, 314).

The bark may be pulped and made into hard boards and insulation boards. It contains: lignin, 36.2; cellulose, 41.1; pentosans, 12.5; and ash, 6.34%. It is mucilaginous and used in external applications for rheumatism (Narayanamurti & Singh, *Composite Wood*, 1955, **2**, 6; Kirt. & Basu, III, 2293).

The seeds (husk, 27.5; kernel, 72.5%) yield 37.4% (53.2% in dry kernel) of a yellow oil with the following characteristics: sp. gr. $^{30°}_{30°}$, 0.9001; $n^{40°}$, 1.4580; acid val., 1.6; sap. val., 203.7; iod. val. (Wij's), 52.78; R.M. val., 0.27; Pol. val., 0.25; unsapon. matter, 3.2%; and solid. pt, 13.5°. The seed cake contains (dry basis): N, 10.3; lysine, 3.3; glutamic acid, 13.0; and histidine, 1.3% (*Chem. Abstr.*, 1951, **45**, 7803; Govindarajan & Ramachandran, *J. sci. industr. Res.*, 1952, **11B**, 477; Krishnamachar & Ramachandran, ibid., 1954, **13B**, 222, 815).

The leaves and young fruits are eaten, though not relished, by livestock. Analysis of the leaves gave the following values (dry basis): crude protein, 13.71; ether extr., 1.86; total carbohydrates, 69.91; ash, 14.52; calcium, 4.25; and phosphorus, 0.15%; *digestible nutrients*—crude protein, 9.35; ether extr., 0.49; carbohydrates, 47.6; and total digestible nutrients, 57.94 lb./100 lb. (Iyyar & Reddy, *Indian For.*, 1942, **68**, 536; Kehar *et al.*, *Sci. & Cult.*, 1957-58, **23**, 94).

**HOLOSTEMMA** R. Br. (*Asclepiadaceae*)

A genus of twining shrubs distributed in south-east Asia. One species occurs in India.

**H. annularis** K. Schum. syn. *H. rheedei* Wall.; *H. rheedianum* auct., non Spreng.

D.E.P., IV, 261; Fl. Br. Ind., IV, 21; Kirt. & Basu, Pl. 624.

SANS.—*Arkapushpi, jivanti*; HINDI—*Chhirvel*; MAR.—*Dudurli, shidodi, tulatule*; GUJ.—*Kharner, khiravel, khirdodi*; TEL.—*Dudipalatige, palagurugu, palatura*; TAM.—*Palay kirai*; MAL.—*Ada kodien, ada modien.*

SANTAL.—*Apung*; DEHRA DUN—*Rani marwi.*

A handsome, extensive, laticiferous twining shrub found in most parts of India, ascending up to an altitude of 6,000 ft. It is grown in gardens for its pretty flowers and may be trained over trellis work. Leaves opposite, ovate or triangular, acute or acuminate, deeply cordate, midrib glandular at the base; flowers in axillary umbellate cymes, purplish inside and silvery white or pinkish outside, fragrant, fleshy; follicles thick, cylindrical, bluntly pointed.

The roots are reported to possess cooling, alterative, tonic and lactative properties. Made into a paste, they are applied in ophthalmia and orchitis; they are also used in diabetes, gonorrhoea, coughs and stomach-ache. Analysis of the root powder gave: moisture, 10.08; protein, 4.07; sugar, 24.0; starch, 35.4; fibre, 12.2; and ash, 3.07%. The ash contained: calcium, 5.6; and phosphate, 2.5% [Kirt. & Basu, III, 1620; Nadkarni, I, 652; Nair & Pillay, *Bull. Res. Inst., Univ. Travancore*, 1951, **2A**(1), 27].

The leaves, flowers and fruits are eaten as vegetable; the plant is also eaten by cattle. The bark yields a fibre reported to be suitable for cordage and paper-making. The plant exudes a latex which on drying yields an elastic residue (Santapau, *Rec. bot. Surv. India*, 1953, **16**, 172).

**HOLOSTEUM** Linn. (*Caryophyllaceae*)

Fl. Br. Ind., I, 226.

A small genus of herbs distributed in the north temperate regions. One species occurs in India.

*H. umbellatum* Linn. is a slender, erect or ascending annual, up to 8 inch in height, with oblanceolate to elliptic, glabrous or glandular ciliate leaves and white or pink flowers in terminal, umbellate cymes. It is found in Kashmir and is said to possess refreshing and slightly demulcent properties (Caius, *J. Bombay nat. Hist. Soc.*, 1936–37, **39**, 564).

**Holy Grass** — *see* **Hierochloe**

**HOMALIUM** Jacq. (*Samydaceae*)

A large genus of trees and shrubs, distributed throughout the tropics. About seven species occur in India.

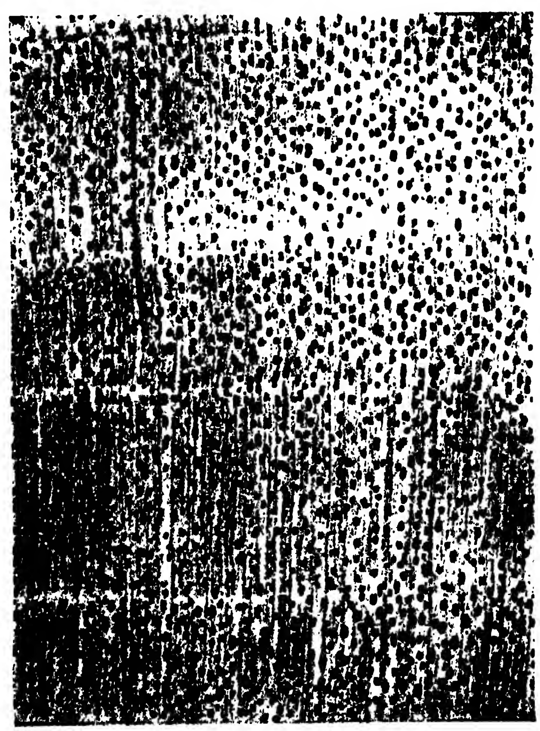
**H. tomentosum** Benth.

D.E.P., IV, 262; Fl. Br. Ind., II, 596; Troup, II, Fig. 231.

A large deciduous tree up to 120 ft. in height and 12 ft. in girth with a straight clean bole of 40–60 ft., found in the Northern Circars and cultivated for ornament in other parts of India. Bark thin, smooth, greyish white; leaves alternate, obovate-oblong, 4–6 in. long, crenate, pubescent beneath; flowers small, subsessile, greenish, in axillary racemes.

*H. tomentosum* prefers a well drained soil, seeds freely and reproduces naturally in abundance. It coppices well. The mean annual girth increment is 0.7 in. (Troup, II, 612).

The wood is greyish white when first exposed, ageing to light greyish brown, with no distinct heartwood, dull, straight-grained and even- to fine-textured. It is very hard, heavy (sp. gr., c. 0.933; wt.,



*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 70. HOMALIUM TOMENTOSUM—TRANSVERSE SECTION OF WOOD (× 10)

60 lb./cu. ft.), strong and elastic (Pearson & Brown, I, 36-38; Bor, 145).

The timber is difficult to air-season and is liable to develop end-splits and surface cracks. Converting the logs when freshly felled and cutting the stock to as small dimensions as permissible, followed by close stacking under cover, give fairly satisfactory results. The timber is also not easy to kiln-season. It is durable, lasts well in exposed positions and is fairly resistant to white ants. It is difficult to saw, especially when seasoned, but works to a smooth and dense surface and takes good polish. It also turns well on a lathe (Pearson & Brown, I, 38; Rodger, 28).

The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 135; strength as a beam, 105; stiffness as a beam, 115; suitability as a post, 110; shock-resisting ability, 130; retention of shape, 55; shear, 160; and hardness, 175. The timber is a medium fuel wood and makes good charcoal. The calorific value of the wood is 4,581 cal., 8,246 B.t.u. [Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 18; *Indian For.*, 1948, **74**, 280; Rodger, 71; Krishna & Ramaswami, *Indian For. Bull.*, No. 79, 1932, 18].

The wood is used for shafts of heavy carts, harrow teeth, hammer handles, furniture, planking, electric transmission poles, masts, spars and fishing rods. It has been found suitable for oil well sucker rods, if well seasoned (Pearson & Brown, I, 38: II, 1080; Rodger, 131; Howard, 251; Limaye, *Indian For. Leafl.*, No. 8, 1941, 3).

*Bot. Dep., Pres. College, Madras*

FIG. 71. HOMALIUM ZEYLANICUM—FLOWERING BRANCH

**H. zeylanicum** Benth.

D.E.P., IV, 262; Fl. Br. Ind., II, 596.

KAN.—*Kal*; MAL.—*Manthala mukki.*

A large ornamental straight tree, up to 100 ft. in height, found in the western ghats from North Kanara southwards up to an altitude of 4,000 ft. Bark smooth, grey; leaves ovate, elliptic or obovate, shortly acuminate, crenate-serrate, shining: young leaves bright red; flowers small, greenish white, fragrant, in panicles.

The wood is greyish red, darker in the centre, even-grained, hard, heavy (wt., 38–52 lb./cu. ft.), strong and durable, but inclined to split. It is used for posts, rafters, curtain rods, shingles and building purposes (Gamble, 381; Bourdillon, 179; Lewis, 209).

## HOMALOMENA Schott (*Araceae*)

A genus of herbs distributed in tropical and subtropical parts of Asia and America. Two species occur in India; a few exotics are grown in gardens.

**H. aromatica** Schott syn. *Calla aromatica* Roxb.

D.E.P., IV, 263; Fl. Br. Ind., VI, 532; Kirt. & Basu, Pl. 1004.

BENG.—*Kuchu gundubi.*

A rhizomatous, aromatic herb found in Assam. Stem short, slow growing; leaves radical with sheathing bases, long petioled, sagittate-cordate, *c.* 1 ft. long, smooth; spadices subcylindric, equalling or longer than the pale greenish yellow spathes; berries oblong, usually one seeded.

The large rhizomes bearing withered leaf scales and numerous white rootlets are esteemed as an aromatic stimulant. Rhizomes are reduced to powder and used in tobacco and snuff compositions. The whole plant is used in skin diseases. The rhizome on steam-distillation yields a yellow essential oil (Kirt. & Basu, IV, 2620; *Indian Tr. J.*, 1953, **185**, 268; Gupta *et al.*, *Indian med. Gaz.*, 1942, **77**, 210).

FIG. 72. HOMALOMENA AROMATICA

*H. rubescens* Kunth syn. *Calla rubescens* Roxb. is a closely related species with reddish leaves and spathes, occurring in Sikkim and Khasi hills. It is also known as *kuchu gundubi* in Bengal and is used in the same manner as *H. aromatica*. In Malaya, it is used as an arrow poison (Kirt. & Basu, IV, 2620).

The rhizomes and roots on steam-distillation yield 5% (on dry basis) of a light yellow, slightly viscous essential oil with pleasant odour resembling that of coriander. Analysis of the oil gave the following values: sp. gr.$^{15°}$, 0.8935; $[\alpha]_D$, $-6.13°$; $n_D$, 1.4719; acid val., 0.4; ester val., 1.4; carbonyl no., 11.1 (cold), 22.4 (warm); solubility in 90% alc., all proportions; and free alcoholic content (expressed as linalool), 75.3%. The oil consists mainly of *l*-linalool (60%), with traces of $\alpha$-terpineol, linalyl acetate and acetic acid. The water-soluble portion of the alcoholic extract yielded three crystalline acids (m.p., 300–301°, 198–200° and 178–180°), resembling *iso*phthalic acid, *m*-hydroxy benzoic acid and hydroxymesilytic acid, besides a small quantity (0.016% on air dry material) of a neutral crystalline substance (m.p., 181–182°) and an amorphous glycoside. The essential oil may be used in perfume compositions (*Chem. Abstr.*, 1953, **47**, 12766, 6095).

**HOMONOIA** Lour. (*Euphorbiaceae*)

A small genus of shrubs and small trees distributed from India to New Guinea. Four species occur in India.

**H. riparia** Lour.

D.E.P., IV, 263; Fl. Br. Ind., V, 455.

SANS.—*Pashanabhedaka, kshudrapashanabheda*; TEL.—*Taniki, siridamanu*; TAM.—*Kattalari*; KAN.—*Holenage, nirganagile*; MAL.—*Kat-allari, vangi kalloor-vanchi*; ORIYA—*Jamla*.

KUMAON—*Kandagar*; NEPAL—*Khola ruis*; LEPCHA—*Mongthel-kung*; ASSAM—*Tuipui-sulhla, hil-kadam, khau-waing-phang*; GOND—*Sundeh*; M.P.—*Surra, bersi*; BOMBAY—*Sarni, sherni*

*Blatter Herbarium, Bombay*

FIG. 73. HOMONOIA RIPARIA—FLOWERING BRANCH

An erect rigid evergreen dioecious shrub found in North, East and Central India, the Deccan Peninsula and Andaman Islands, usually inhabiting rocky river-beds. Bark rough, dark grey or brown ; leaves willow-like, lanceolate or linear-oblong, entire or serrulate towards the apex, glabrous above, clothed beneath with small orbicular scales, aromatic ; flowers sessile, in axillary spikes ; capsules globose, tomentose ; seeds roundish, yellow brown or crimson.

The root is laxative, diuretic and emetic. A decoction of the root is given in piles, stone in the bladder, gonorrhoea, syphilis and chest pain. In the Philippines, it is used as a mouth-wash for toothache (Kirt. & Basu, III, 2273 ; Rama Rao, 372 ; Fox, *Philipp. J. Sci.*, 1952, **81,** 341).

Pounded leaves and fruits are applied as a poultice for skin diseases. The juice of the leaves and shoots is regarded as depurative and used as an application for hair and also as a drink in Cambodia. In Java, the juice of the plant is used for blackening teeth and making them firm. In the Philippines, the mash obtained by chewing leaves is rubbed on wounds caused by scorpion fish. In Cambodia, an infusion of the wood is given in malaria (Burkill, I, 1186–87 ; Fox, *Philipp. J. Sci.*, 1952, **81,** 336).

Tender leaf tops are used as vegetable in the Philippines. The plants are grown along river banks, for strengthening them, in Java (Fox, *Philipp. J. Sci.*, 1952, **81,** 238).

The wood is greyish brown, close-grained, moderately hard and heavy (wt., 40 lb./cu. ft.). It is reported to be used for the framework of goggles used by divers in the Philippines (Gamble, 622 ; Fox, *Philipp. J. Sci.*, 1952, **81,** 280).

**Honey** — *see* **Bees**

**Honey Locust, Common** — *see* **Gleditsia**

**Honeysuckle** — *see* **Lonicera**

**Honeysuckle, French** — *see* **Hedysarum**

**Hoop Pine** — *see* **Araucaria**

**HOPEA** Roxb. (*Dipterocarpaceae*)

A genus of timber trees distributed in the Indo-Malayan region. Some of the species yield resins and tannins. About 10 species occur in India.

**H. glabra** Wight & Arn.

D.E.P., IV, 271 ; Fl. Br. Ind., I, 309.

TAM.—*Kongu, karaikkongu* ; KAN.—*Malehegge* ; MAL.—*Ilappongu.*

A moderate-sized tree found in the ghats of Tinnevelly and Travancore. Bark blackish brown ; leaves lanceolate, obtuse or shortly acuminate, glabrous ; flowers creamy yellow, in axillary panicles ; fruit ovoid, winged.

The wood is light grey or creamy brown with white lines at irregular intervals, interlocked-grained, fine- and even-textured, very hard and heavy (sp. gr., 1.05 ; wt., 67 lb./cu. ft.). The timber, if not properly seasoned, develops end splits and surface cracks ; logs left to lie in forests for several months yield sound material on conversion. The timber is durable and immune to insect attack ; untreated sleepers gave an average life of 12 years or more in graveyard tests. The wood saws and machines well and can be finished to a smooth shiny surface taking a good polish. It is used for beams, posts and rafters in construction work and for carts (Pearson & Brown, I, 98–100 ; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49, Fig. 2/2).

**H. odorata** Roxb.

D.E.P., IV, 271 ; Fl. Br. Ind., I, 308.

TAM.—*Urappuppicin* ; KAN.—*Bilitirupu, kallurala* ; MAL.—*Urappimpasa.*

ANDAMANS—*Thingan, rimda.*

TRADE—*Thingan, White Thingan.*

A tree up to 150 ft. in height and 12 ft. in girth, with a clean cylindrical bole up to 80 ft., found in Andaman Islands. It occurs sporadically in pure groups, but is not gregarious over large areas. The tree is sometimes cultivated in Bengal and parts of the western coast. Bark grey to dark brown with longitudinal furrows ; leaves ovate-oblong, acute or bluntish acuminate, entire or wavy ; flowers small, yellowish white, fragrant, in racemes ; fruits ovoid, winged.

The tree thrives on damp rich soil and stands a considerable amount of shade in the earlier stages. The fruits ripen in May-June and germinate soon after they fall (Troup, I, 47).

The sapwood is pale yellow ; heartwood yellow to olive brown, purplish on exposure, with lustrous white resin canals becoming dull with age, even-grained, close-textured, very hard and heavy (sp. gr., *c.* 0.65 ; wt., 47 lb./cu. ft.). It is slow drying and liable to surface cracking. Green conversion and stacking under cover have been recommended. The timber can be kiln-seasoned without difficulty (Rodger, *Indian For. Bull.*, No. 49, 1922 ; Pearson & Brown, I, 101–2 ; Trotter, 1944, 119).

The timber is very durable ; untreated sleepers last

15 years or more. The wood is immune to white ants but is liable to attack by borers. It is difficult to saw but can be finished to a good surface (Pearson & Brown, I, 102; Trotter, 1944, 119–20).

The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 110; strength as a beam, 100 stiffness as a beam, 100; suitability as a post, 95 shock resisting ability, 100; retention of shape, 75 shear, 110; and hardness, 130 [Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 18].

Thingan is chiefly used for boat building, dug-outs and for constructional purposes. It is also used for carts, oil and sugarcane presses, flooring, roofing, piles, fence posts, ploughs, brush backs, furniture, ships blocks, bits and capstan bars. It is a first class sleeper wood (Pearson & Brown, I, 103; Rodger, 135; Rodger, *Indian For. Bull.*, No. 49, 1922).

The tree yields a resin known as ROCK DAMMAR in commerce. The resin consists of large, yellow, irregular tears with slight odour and shiny fracture. It has the following characteristics: m.p., 115°; sap. val., 37.1; acid val., 31.5; and ash, 0.56%. It is completely soluble in turpentine oil and partially in alcohol. The resin has been classed commercially as a second quality dammar and can be used in the preparation of varnishes for indoor decorative work. It is also used for painting pictures, caulking boats, and mounting microscopic objects. A composition prepared by mixing the resin with beeswax and red ochre is used for fastening spear and arrowheads. The resin has styptic properties and is used by the Burmese as an ointment for wounds and sores (*Bull. imp. Inst., Lond.*, 1904, **2**, 23; Rodger, *Indian For. Bull.*, No. 49, 1922; Kirt. & Basu, I, 291).

The leaves, bark and wood contain 11, 13-15 and 10% tannin respectively and are used for tanning. The bark yields a supple pale leather; the leaves have a softening effect and are used for finishing mangrove-tanned leathers. The bark is astringent and used as masticatory and for gums [Howes, 1953, 279; Edwards *et al., Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 152; Kirt. & Basu, I, 291; Burkill, I, 1193].

**H. parviflora** Bedd.

D.E.P., IV, 273; Fl. Br. Ind., I, 308.

TAM.—*Kongu, vellai kongu, pongu, agil, irumbugam;* KAN.—*Tirupu, bovige, kiralboghi, bovumara;* MAL.—*Thambagam.*

TRADE—*Hopea.*

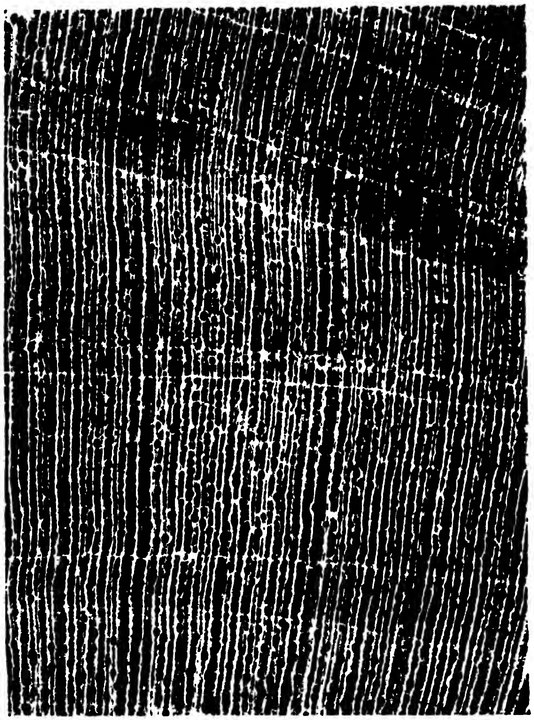
A tree up to 120 ft. in height and 18 ft. in girth, with a clean bole of 50–60 ft., occurring in the western ghats from North Kanara southwards. Bark rusty brown and smooth in young trees, becoming rough and exfoliating in older ones; leaves ovate-oblong, *c.* 3.5 in. × 1.5 in., undulate, bluntly acuminate, glabrous; flower small, cream-coloured, fragrant in tomentose panicles; fruit a small nut with two straw coloured wings. The tree when young has a conical crown which becomes more rounded and dense with age.

Hopea prefers a rich deep moist soil and grows best alongside streams and in moist valleys, but sometimes thrives even on dry hard laterite. It is essentially a semi-shola tree requiring close proximity of running water for its growth (Troup, I, 48).

The tree reproduces freely in nature. The fruits ripen in May-June and germinate within a few days after reaching the ground. Artificially, hopea can be raised by sowing seed and transplanting the entire

*Supt., Lalbagh Gardens, Bangalore*

FIG. 74. HOPEA PARVIFLORA—FLOWERING BRANCH



*F.R.I., Dehra Dun. Photo : S. S. Ghosh*

FIG. 75. HOPEA PARVIFLORA—TRANSVERSE SECTION OF WOOD (× 10)

seedlings. The tree is not a heavy shade bearer, but benefits by shade in the seedling stage. The rate of growth is moderately fast. In favourable situations hopea is gregarious forming nearly pure forests.

According to the conditions of the crop, hopea forests are managed under selection fellings, irregular shelterwood fellings, improvement fellings and the like (Kadambi, *Indian For.*, 1954, **80,** 390).

Hopea has been reported to be affected by honey combed rot caused by *Fomes lamaoensis* (Murr.) Sacc. & Trott. and white pocket rot caused by *Trametes spongipellis* Lloyd (*Indian J. agric. Sci.*, 1950, **20,** 107).

The wood is reddish brown with occasional white lines, turning darker with a purplish cast on ageing, dull, smooth, interlocked-grained, even- and fine-textured. It is hard, heavy (sp. gr., *c.* 0.70 ; wt., 58–62 lb./cu. ft.) and strong (Pearson & Brown, I, 96 97).

The timber seasons well. It is best converted green to prevent borer damage and stacked in shade to dry. The wood is very durable, even in contact with ground and water, and is immune to white ants. Untreated sleepers gave an average life of 22 years or more in graveyard tests. Hopea timber is difficult to saw and work, but takes a good polish (Pearson & Brown, I, 97 ; Kadambi, loc. cit. ; Purushotham *et al.*, *Indian For.*, 1953, **79,** 49, Fig. 2/1).

The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: wt., 135 ; strength as a beam, 120 ; stiffness as a beam, 120 ; suitability as a post, 120 ; shock resisting ability, 130 ; retention of shape, 65 ; shear, 155 ; and hardness, 200. The timber is a very good fuelwood ; calorific value of sapwood is 5,078 cal., 9,141 B.t.u. [Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 18 ; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 18].

The wood is much valued for construction work and is extensively used for house building, parts of ships, boat building, piles for bridges, road rammers, rice pounders, platform boards, setts, ladders, mill tables, and engine break blocks. It is also used for carts and carriages, railway keys, picker arms and for decorative woodwork and turnery. It has been used for railway sleepers and electric transmission poles, but is too valuable to be so exploited. It is used for beaming in Kolar goldfields (Kadambi, loc. cit. : Pearson & Brown, I, 97 ; Trotter, 1944, 120, 200, 222).

The bark is considered a good tanning material, especially for heavy leather. It contains 14–28% pyrocatechol tannins and 5–10% non-tannins. It is

*Blatter Herbarium, Bombay*

FIG. 76. HOPEA WIGHTIANA—FLOWERING BRANCH AND FRUITS

*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 77. HOPEA WIGHTIANA—TRANSVERSE SECTION OF WOOD (× 10)

very astringent, with a slow speed of diffusion and is particularly suitable for tanning in admixture with other tanstuffs. Tanning with a mixture of 2 parts of hopea and 1 part of myrobalan barks produced a reddish brown leather of good quality which compared favourably with wattle-tanned leather and was more resistant to mould growth. The mixture is recommended to the tanning industry. The high proportion of tannins to non-tannins in the bark and the ease with which the tannin can be extracted render it suitable for the manufacture of tanning extracts; a solid extract containing 70% tannin and 22.6% non-tannin has been prepared [Howes, 1953, 279; *Chem. Abstr.*, 1930, **24**, 3919; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 78; Rao *et al.*, *Bull. cent. Leath. Res. Inst., Madras*, 1954–55, **1**(3), 5; Mathew & Das, ibid., 1954–55, **1**(5), 6].

**H. wightiana** Wall.

D.E.P., IV, 273; Fl. Br. Ind., I, 309.

MAR.—*Kavsi, kalhoni*; TAM.—*Ilapongu*; KAN.—*Nai irupu, haiga, kalbovu, hiribovige, unni*; MAL.—*Pongu.*

A moderate to large-sized tree, with a fluted and somewhat tapering stem, found in the evergreen forests of west coast from Konkan southwards. Bark smooth, exfoliating in rectangular pieces; leaves oblong-lanceolate, 5–8 in. × 2–3 in., obtuse or acute, glabrous; flowers pinkish white, in copious axillary panicles; fruits ovoid, winged, crimson.

The tree is affected by spongy heart rot or butt rot caused by *Fomes badius* Berk. (*Indian J. agric. Sci.*, 1950, **20**, 107).

The wood is reddish brown with occasional white lines, lustrous, irregularly interlocked-grained, fine- and even-textured, hard, heavy (sp. gr., *c.* 1.06; wt., 62–68 lb./cu. ft.) and strong. The timber is liable to surface cracking; prompt conversion immediately after felling has been recommended. It is fairly durable and moderately hard to saw and work (Pearson & Brown, I, 93–95).

The wood is used for beams, rafters, posts and piles in construction work and for cart wheels. It has been recommended for cabinet work, brush backs, inlay and turnery. It yields an excellent fuel (Pearson & Brown, I, 95; Howard, 254).

*H. racophloea* Dyer and *H. canarensis* Hole are found in south western ghats. The timbers of both the species are said to be useful.

## HOPPEA Willd. (*Gentianaceae*)

A small genus of herbs distributed from India to Philippines. Two species occur in India.

**H. dichotoma** Willd.

Fl. Br. Ind., IV, 100.

A small divaricately branched herb, up to 6 in. high, found almost throughout India up to an altitude of 3,000 ft. Stems quadrangular, more or less winged; leaves opposite, sessile, ovate, ¼ in. × ⅛ in.; flowers small, greenish white or pale yellow, in 2–3 chotomous cymes; capsules ellipsoid, *c.* 2 mm. long.

The plant is used in piles and in snake bite. The Mundas use the roots in epilepsy (Kirt. & Basu, III, 1658; Bressers, 95).

**Hops** — *see* **Humulus**

## HORDEUM Linn. (*Gramineae*)

A genus of annual or perennial grasses widely distributed in temperate and subtropical regions of the world. Four species occur in India.

The genus includes both wild and cultivated forms of barley. It has been divided into four sections,

namely, *Stenostachys*, *Campestria*, *Bulbohordeum* and *Cerealia*, of which the last mentioned, which includes all cultivated barleys is economically important.

The classification of cultivated barleys is rather confused and various suggestions have been put forward regarding their nomenclature and delimitation of species, varieties or races. Earlier classifications were based mainly on morphological characters. Some of them are: variation in the fertility of spikelets, density of spikes (as measured by the length of internodes on rachis, or number of spikelets per unit length of rachis), colour and adherence or non-adherence of hull or husk (lemma and palea) to caryopsis (grain), form and size of awn and glume, serration of awn, character of the base of grain, character of rachilla and serration of veins of dorsal palea, and size and hairiness of rachilla. The most conspicuous variation among cultivated types is in the fertility of spikelets. This variation forms the basis for the division of cultivated barleys into two groups, six-rowed and two-rowed. All spikelets in six-rowed barleys are fertile, with lemma awned or hooded, while in two-rowed barleys, only median spikelets are fertile. However, it is not possible to split cultivated types on the basis of fertility of spikelets alone, since all intergradations from two-rowed to six-rowed types are met with. Consequently cultivated barleys are grouped often under *H. vulgare* Linn., which is considered a cultigen embracing all the types (Beaven, 17–25; Hunter, 6–15; Aberg & Wiebe, *Tech. Bull. U.S. Dep. Agric.*, No. 907, 1946; Hector, I, 259–63; Hector, *S. Afr. J. Sci.*, 1932, **29**, 332; Hill, 320; Schery, 388; Ames, 111; Mansfield, *Züchter*, 1950, **20**, 8; Takahashi, *Advanc. Genet.*, 1955, **7**, 227).

FIG. 78. HORDEUM VULGARE: TYPES OF EARHEADS—2-ROWED AWNED (left); 6-ROWED AWNED (middle); 6-ROWED HOODED (right)

On the basis of studies of a large collection of barley types from various regions of the world, Vavilov suggested two principal centres of diversity: the first centre, pivoting round north-east Africa and mountainous districts of Abyssinia where two-rowed, long-awned, hulled types are predominant, and the second centre in eastern Asia, comprising China, Japan, Tibet and Nepal, where six-rowed, huskless, short-awned, awnless or hooded types are dominant. The discovery of a six-rowed wild barley, *H. agriocrithon* Aberg, from Tibet lends support to the hypothesis that the home of cultivated barleys is within inner Asia and that two-rowed types are derived from a six-rowed ancestral form (Arber, 11; Fl. Egypt, I, 294; Takahashi, loc. cit.).

All cultivated types of barley have 7 pairs of chromosomes. Among wild forms, species with 7, 14 and 21 pairs of chromosomes occur. Barley is a self-fertilising plant and natural crossing is very low—less than 0.5% in most types—being more common in naked than in covered types. Hybridisation of cultivated barleys is more difficult than in the case of wheat (Smith, *Bot. Rev.*, 1951, **17**, 133).

**H. vulgare** Linn. (*H. sativum* Jessen); including *H. hexastichon* Linn.; *H. intermedium* Körnicke; *H. distichon* Linn.; *H. zeocriton* Linn.; *H. deficiens* Steud.; and *H. aegiceras, H. coeleste, H. gymnodistichum* of Watt. BARLEY

D.E.P., IV, 274; V, 128; C.P., 640; Fl. Br. Ind., VII, 371; Bailey, 1949, 45.

SANS.—*Yava*; HINDI—*Jau, jav*; BENG.—*Jab, jau*; MAR.—*Java*; GUJ.—*Jau, jav, ymvah*; TEL.—*Barlibiyam, yavaka*; TAM.—*Barliyarisi*; KAN.—*Jave godhi*.

BIHAR—*Jowakhar*; PUNJAB—*Jaon*.

An annual erect, stout, tufted herb, 2–4 ft. high, resembling wheat in habit; leaves few, linear-lanceolate, upper one close to the spike; sheath smooth, striate; ligules short, membranous; spikes terminal, linear-oblong, compressed, 2–2½ in. long, densely flowered; spikelets sessile, arranged in threes on two sides of a flattened rachis, all fertile (6-rowed type), or lateral ones barren and occasionally rudimentary (2-rowed type); glumes 2, small, narrow, short-awned, enclosing three spikelets; lemma lanceolate, five-ribbed, tapering into a long straight or recurved awn; palea a little smaller than lemma, with margins

inflexed ; lodicules 2 ; stamens 3 ; stigmas 2 ; fruit a caryopsis, elliptic, c. 3/8 in. long, short-pointed, grooved on the inner face, smooth, free or adherent to palea or both to lemma and palea.

Barley is one of the oldest of cultivated cereals and is extensively used as food and cattle feed and for malting, brewing and pearling. In the temperate regions of the northern hemisphere, it has developed into an important crop. The important producers of barley are U.S.S.R., China, U.S.A., Canada, India and countries bordering the Mediterranean, which together contribute more than 50% of the total world production. Table 1 gives the acreage and production

TABLE 1—ACREAGE & PRODUCTION OF BARLEY IN IMPORTANT COUNTRIES*

| Country | Area (thousand acres) 1950/51–1954/55 (av.) | Area (thousand acres) 1955–56 | Production (thousand tons) 1950/51 1954/55 (av.) | Production (thousand tons) 1955-56 |
|---|---|---|---|---|
| U.S.A.† | 10,173 | 14,564 | 6,065 | 8,598 |
| Canada | 7,919 | 9,932 | 4,893 | 5,409 |
| India‡ | 8,110 | 8,155 | 2,665 | 2,721 |
| Eastern Europe§ | 6,840 | 6,600 | 3,700 | 4,500 |
| Turkey | 5,540 | 6,523 | 2,751 | 2,938 |
| Morocco | 4,844 | 4,725 | 1,470 | 1,181 |
| Spain | 3,922 | 3,825 | 1,878 | 1,691 |
| Algeria | 3,138 | 4,304 | 800 | 664 |
| France | 2,713 | 3,254 | 1,915 | 2,629 |
| Iraq | 2,480 | 2,977 | 924 | 756 |
| Iran** | 2,292 | n.a. | 983 | 1,033 |
| Japan | 2,397 | 2,451 | 2,138 | 2,369 |
| U.K. | 2,051 | 2,296 | 2,150 | 2,936 |
| Western Germany | 1,722 | 1,925 | 1,754 | 2,046 |
| South Korea | 1,644 | 1,861 | 468 | 782 |
| Argentina | 1,586 | 2,037 | 842 | 936 |
| Australia | 1,414 | 1,894 | 672 | 930 |
| Denmark | 1,390 | 1,309 | 1,917 | 2,165 |
| U.S.S.R.†† | 23,000 | 30,000 | 7,300 | 7,000 |
| China** | n.a. | n.a. | n.a. | n.a. |

* *Grain Crops*, Commonwealth Econ. Comm., 1957, Tables 49 & 50. † Harvested for grain: area (in thousand acres) sown for all purposes: 1951–1955 (av.), 11,549 and 1955–56, 16,102. ‡ Data according to *Agric. Situat. India*, 1956–57, **11**, 534–557. § Estimate: includes Roumania, Hungary, Bulgaria, Czechoslovakia, Poland and Eastern Germany. ** Average for 4 years only. †† Estimate. ‡‡ Estimated averages for 1937–38 to 1939–40 were 16,500 (thousand acres) and 5,700 (thousand tons). n.a. not available.

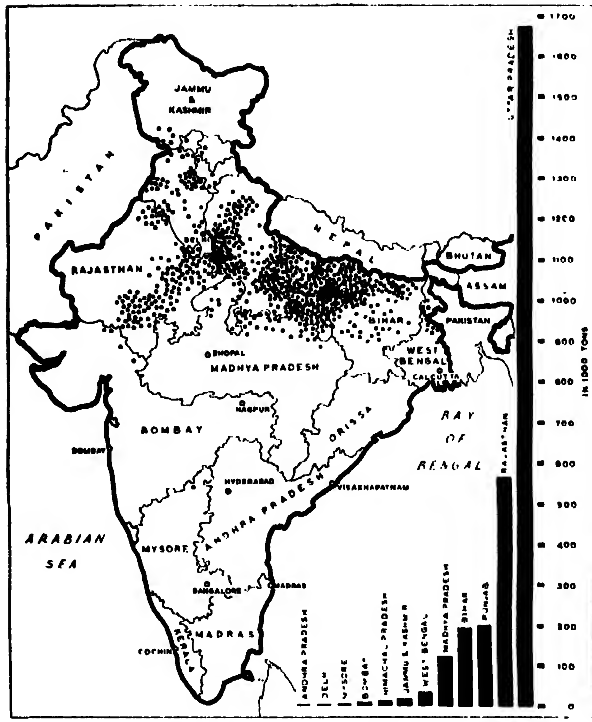



FIG. 79. ACREAGE & PRODUCTION OF BARLEY IN INDIA
(av. 1953/54 - 1955/56 ; • -- 10,000 acres)

of barley in important countries (Bell, *World Crops*, 1949, **1**, 143 ; Shands & Dickson, *Econ. Bot.*, 1953, **7**, 3 ; van Royen, I, 71).

Barley has been cultivated since long in northern India. It is grown in the plains as well as in the hilly regions of the Himalayas, up to an altitude of 14,000 ft. The bulk of the crop is concentrated in the Indo-Gangetic area and the adjoining tracts of Madhya Pradesh. The chief producing States, in the order of importance, are Uttar Pradesh, Rajasthan, Bihar, Punjab and Madhya Pradesh. Other States producing barley are West Bengal, Himachal Pradesh, Jammu & Kashmir and Bombay. The annual aggregate area under barley is estimated at 8 million acres. Table 2 gives the acreage and production of barley in different Indian States (*Agric. Marketing India, Rep. Marketing Barley, Marketing Ser.*, No. 51, 1945, 2).

The chief producing districts of U.P. are Azamgarh, Gorakhpur, Jaunpur, Allahabad, Basti, Aligarh, Deoria and Bulandshahr. In Bihar, the three districts of Champaran, Saran and Muzaffarnagar produce nearly half the total in the State.

*Cultivated types* -Attempts have been made to collect and classify the numerous types of barley from different parts of India. Twenty-four types have been

isolated, of which five are 2-rowed and nineteen are 6-rowed. These types have been again sub-divided on the basis of the adherence of lemma to caryopsis, as husked or huskless and also according to grain colour. The 6-rowed husked types are the most widely grown in India and the 2-rowed types, both husked and huskless, are grown to a very limited extent; the 6-rowed huskless form is rarely grown. Outside India, 6-rowed forms of widely varying types, many of winter and others of spring habit, some husked and others huskless, are under cultivation. In north-west Europe and Germany, however, where the climate is more temperate, 2-rowed spring forms predominate and these furnish barleys of high malting quality (Rama Prasada, *Bull. Dep. Agric., U.P.*, No. 43, 1926; Bose, *Indian J. agric. Sci.*, 1931, **1**, 58; Hunter, 33).

Considerable work on evolving suitable types of barleys has been carried out in various countries. In India, pure line selections have been made mainly from indigenous materials suitable for various barley growing areas. So far not much breeding work has been done. Table 3 summarises the information on the selections made in India (Shaw & Bose, *Agric. J. India*, 1929, **24**, 373; Pal, *Indian J. Genet.*, 1957, **17**, 148).

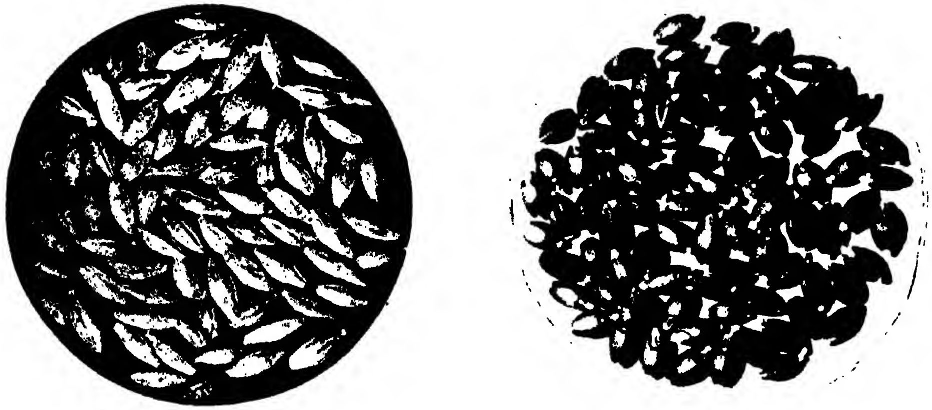
*Climate*—Barley has been cultivated widely because of the existence of forms adapted to varying climatic and soil conditions. There are types that survive under extreme conditions and mature in as short a period as 60–70 days; this enables their cultivation at high altitudes and as far north as the Arctic circle. Due to its ability to ripen at comparatively high temperatures the southern limit for its cultivation is 10° N of equator. Barley is not particularly winter-hardy; it is therefore grown as a spring crop in northern Europe; in regions with comparatively mild winter, e.g. Mediterranean region and India, it is cultivated as a winter crop. It is heat- and drought-resistant, and has been successfully grown in sub-tropical and semi-arid regions. It requires during its period of vegetative growth an average temperature of 15.5–17°, preferably with sunny weather and moderate precipitation. Dry warm weather is favourable for grain ripening. Barley does not thrive well in humid, warm climates (van Royen, I, 71; Bell, *World Crops*, 1949, **1**, 143; Shands & Dickson, *Econ. Bot.*, 1953, **7**, 3).

*Soil*—Barley can be grown on soils which are too light or otherwise unsuitable for wheat cultivation. It does well on light or sandy loam soil. It is

TABLE 2—STATE-WISE ACREAGE & PRODUCTION OF BARLEY IN INDIA*

| | Area (thousand acres) | | | | | Production (thousand tons) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 |
| Uttar Pradesh | 4,661 | 4,801 | 5,084 | 4,808 | 4,813 | 1,485 | 1,765 | 1,758 | 1,714 | 1,549 |
| Rajasthan | 764 | 1,002 | 1,213 | 1,274 | 1,339 | 334 | 530 | 531 | 540 | 612 |
| Bihar | 881 | 990 | 1,126 | 899 | 778 | 131 | 198 | 214 | 192 | 181 |
| Punjab | 799 | 474 | 566 | 617 | 497 | 214 | 165 | 214 | 215 | 173 |
| Madhya Pradesh | 402 | 478 | 375 | 410 | 415 | 87 | 167 | 102 | 135 | 136 |
| West Bengal | 114 | 77 | 128 | 107 | 109 | 36 | 26 | 36 | 32 | 29 |
| Himachal Pradesh | 71 | 69 | 73 | 73 | 77 | 17 | 12 | 13 | 14 | 15 |
| Jammu & Kashmir | 50 | 69 | 78 | 50 | 50 | 14 | 8 | 21 | 14 | 14 |
| Bombay | 30 | 34 | 38 | 36 | 36 | 7 | 6 | 8 | 9 | 8 |
| Delhi | 18 | 13 | 15 | 13 | 12 | 2 | 1 | 2 | 1 | 1 |
| Andhra Pradesh | 10 | 5 | 8 | 9 | 8 | 1 | (b) | 1 | 2 | 1 |
| Mysore | 6 | 7 | 13 | 11 | 9 | 2 | 4 | 5 | 2 | 2 |
| Orissa | 1 | 1 | 1 | 1 | 1 | (b) | (b) | (b) | (b) | (b) |
| Madras | (a) | 1 | 1 | 1 | 1 | (b) | (b) | (b) | (b) | (b) |
| TOTAL | 7,807 | 8,021 | 8,719 | 8,309 | 8,155 | 2,330 | 2,882 | 2,905 | 2,870 | 2,721 |

* *Agric. Situat. India*, 1956–57, **11**, 534 57. (a) below 500 acres. (b) below 500 tons.



Husked | Huskless

FIG. 80. HORDEUM VULGARE—SEED TYPES

TABLE 3—CHARACTERISTICS OF IMPORTANT BARLEY TYPES SELECTED IN INDIA

| Type | Characteristics | Areas under cultivation or recommended for cultivation |
|---|---|---|
| N.P. 12[1] | Early maturing; kernel hulled, light yellow, long and rather plump (bushel wt., 48 lb.); high yielding | Uttar Pradesh |
| N.P. 13[1] | Medium maturing; kernel hulled, light yellow, long and thin (bushel wt., 47 lb.); fairly resistant to smut | Bihar, Delhi, Himachal Pradesh & Rajasthan |
| N.P. 20[1] | Early maturing; kernel hulled, white, long and plump (bushel wt. 47 lb.); high yielding | Bihar, Delhi, Himachal Pradesh & Rajasthan |
| N.P. 21[1,2,4] | Early maturing; kernel hulled, white, with a purplish tinge, long and plump (bushel wt., 45 lb.); fairly resistant to lodging and leaf stripe, susceptible to smut; high yielding, moderately good malting quality | Uttar Pradesh (except western U.P. and Bundelkhand), Bihar & West Bengal |
| K. 251[2,3,5] | Early maturing; grain long and plump, bright straw-coloured, good malting quality; high yielding; suitable for unirrigated lands | Uttar Pradesh & Jaipur |
| K. 12[11] | In yield compares favourably with N.P.21 & K.251; resistant to lodging, and smut and stripe diseases. | Uttar Pradesh |
| T. 4[2,6,7] | Early maturing; kernel plump and heavy; husk yellowish, aleurone layer amber-coloured; susceptible to lodging; high yielding, suitable for poor soils or late sowing; very good for malting and brewing | South-eastern Punjab, Rajasthan, Delhi & Himachal Pradesh |
| T. 5[2,7] | Late maturing; husk brightly coloured; aleurone layer blue, kernel plump, rounded, heavy; fairly good for malting and brewing; resistant to lodging; requires comparatively richer land and better water supply | South-eastern Punjab, Rajasthan, Delhi & Himachal Pradesh |
| C. 138–2[8] | Kernel bright, amber coloured; fairly resistant to yellow rust; high yielding | Punjab |
| C. 144[3,8,9] | Mid-season maturing; grains bold and bright, suitable for malting and brewing; fairly resistant to lodging, yellow rust and covered smut; requires relatively less water and can thrive on alkali lands | Punjab |
| C. 155[3,9] | Resistant to covered smut; suitable for malting, brewing, pearling and powder products | Punjab |
| B.R.22[10] | Comparatively less susceptible to covered smut; high yielding | Bihar & Orissa |

[1] Bose, *Indian J. agric. Sci.*, 1931, **1**, 81-84; [2] Sen, *Indian Fmg, N. S.*, 1952-53, **2**(5), 8; [3] Pal, *Indian Coun. agric. Res., Souvenir*, 1929-54, 17; [4] Shaw *et al.*, *Agric. J. India*, 1930, **25**, 527; [5] Ansari, *Indian Fmg*, 1943, **4**, 569; [6] Singh & Dass Gupta, *Punjab Fmr*, 1953, **5**(3), 19; [7] Roberts & Kartar Singh, 246; [8] Ahlawat, *E. Punjab Fmr*, 1949, **1**(1), 18; [9] *Annu. Rep. Dep. Agric., Punjab*, 1953-54, 56; [10] Singh, *Proc. Bihar Acad. agric. Sci.*, 1955, **4**, 75; [11] Mehta, *Agric. Anim. Husb., Uttar Pradesh*, 1951, **2**(4), 3.

tolerant to alkalinity, frost and drought and is less exacting in its nutritive requirements than wheat. The highest grades of barley are produced in fertile, deep loam soils with a *p*H of 7 to 8. For malting barleys, the soil should not contain too much nitrogen (Hunter, 170 : Dutt & Pugh, 302 : van Royen, I, 71).

*Culture* Barley is generally raised in India as a rabi crop, sown in October-November and harvested by the end of March or beginning of April. In Punjab, sowing is sometimes done as late as early January. The crop is raised under both rainfed and irrigated conditions. About 46% of the total area under barley is irrigated (Table 4).

Barley is grown pure, but quite often it is grown in mixture with gram, pea, lentil, linseed, berseem, *senji*, rape and mustard. In Punjab and U.P., it is sometimes grown mixed with wheat as an insurance against weather hazards. The area under mixed barley crop is estimated at 40% of the total barley acreage (*Rep. Marketing Barley*, 1945, 4).

For sowing barley, the land is prepared in the same way as for wheat or oats. The seed rate varies according as the crop is irrigated or not and the method of sowing; it is higher than for wheat and ranges between 50 and 120 lb. per acre. Seeds are sown broadcast or in shallow furrows, about 9 in. apart, seeds being dropped through a drill. The depth of sowing is ½–1½ in. (Yegna Narayan Aiyer, 114 ; *Indian J. agric. Sci.*, 1949, **19**, 508 ; Roberts & Kartar Singh, 125, 247).

The crop requires very little interculture or weeding. In dry areas, 2 or 3 waterings are required after sowing. Irrigation increases the yield ; also barleys grown under irrigated conditions contain less nitrogen than those grown under unirrigated conditions. In U.P., a light harrowing after the first irrigation when the crop is not more than 8 in. high is reported to have given 10% higher yield. Barley is grown generally without any special manuring [Milne *et al.*, 8 ; Mukerji & Agarwal, *Indian J. agric. Sci.*, 1944, **14**, 109 ; *Indian Fmg, N.S.*, 1954-55, **4**(4), 31].

Application of nitrogenous, phosphatic and potassic fertilizers in various combinations influence the yield and quality of grain. Addition of nitrogen increases yields of straw and grain ; in larger doses, it increases the protein content of grain and thereby affects its brewing quality. Under Indian conditions, the use of nitrogenous manures in small doses (40 lb. per acre) has given significantly higher yields without affecting the grain quality. Phosphatic fertilizers lower the protein content considerably and influence ear formation and ripening (Hunter, 176 ; Mukerji & Agarwal, loc. cit.).

Lodging in barley is not so common as in wheat. Where it occurs, it causes considerable losses both in the quality and yield of crop. Lodging may be due to poor root system, weak straw, disease infection, or storm damage. High soil fertility, excessive nitrogenous manure, lack of phosphate or potash in soil, high seed rate and wide row spacing may result

TABLE 4—STATE-WISE ACREAGE OF BARLEY UNDER IRRIGATION*

(in thousand acres ; figures in brackets show % of irrigated to total cultivated area)

| State | 1950-51 | | 1951-52 | | 1952-53 | | 1953-54 | |
|---|---|---|---|---|---|---|---|---|
| | Irrigated | Total | Irrigated | Total | Irrigated | Total | Irrigated | Total |
| Uttar Pradesh | 2,229 (46.3) | 4,812 | 2,393 (51.3) | 4,661 | 2,393 (49.8) | 4,801 | 2,625 (51.7) | 5,084 |
| Rajasthan | 674 (91.0) | 741 | 697 (91.0) | 764 | n.a. | 1,002 | 903 (74.4) | 1,213 |
| Bihar | 148 (16.4) | 902 | 139 (15.8) | 881 | 137 (13.8) | 990 | 140 (12.4) | 1,126 |
| Punjab | 165 (30.3) | 544 | 236 (29.5) | 799 | 242 (51.0) | 474 | 209 (37.0) | 566 |
| Madhya Pradesh | 129 (29.3) | 440 | 138 (34.3) | 402 | 140 (29.3) | 478 | 112 (29.9) | 375 |
| Others | 72 (28.4) | 254 | 82 (27.3) | 300 | n.a. | 276 | 74 (20.8) | 355 |
| TOTAL | 3,417 (44.4) | 7,693 | 3,685 (46.7) | 7,807 | n.a. | 8,021 | 4,063 (46.6) | 8,719 |

* *Agric. Statist. Reorganised States*, 1956. n.a. not available.

in weak straw. Lodging can be reduced to some extent by cultural practices, e.g. balancing the soil fertility, and by evolving strains resistant to lodging. Types *N.P. 21* (Pusa), *K. 12* (U.P.), *Type No. 5* and *C. 144* (Punjab) are reported to be resistant to lodging (Bose, loc. cit.; Roberts & Kartar Singh, 246; Moore, *Agriculture, Lond.*, 1949–50, **56,** 314; Sisler & Olson, *Sci. Agric.*, 1951, **13,** 177; Mehta *et al.*, *Sci. & Cult.*, 1953–54, **19,** 152).

*Diseases*—The most widely distributed disease of barley is covered smut, caused by *Ustilago hordei* (Pers.) Lagerheim. It appears in the barley head as black masses which replace the kernel. The spore masses, which are covered and held together by the ovary wall and glumes, are released during threshing and adhere to healthy seeds. Covered smut is thus an externally seed-borne disease. The disease is controlled by spraying fungicidal dusts, such as Ceresan, Spergon, Agrosan, formalin dust and sulphur dust. Shallow sowing or irrigation immediately after sowing is reported to reduce the incidence of disease. In Punjab, delayed sowing of late maturing types have helped in reducing infection. Moistening of seeds with formalin solution (1 lb. of commercial formalin in 40 gallons of water) for four hours has also proved effective. Strain *K 12* (U.P.), *B.R. 22* (Bihar), and *C. 153*, *C. 144* and *C. 141* (Punjab) are reported to be resistant to covered smut (Mundkur, 138–40; Milne *et al.*, 8–9; Dutt & Pugh, 304; Mehta *et al.*, *Sci. & Cult.*, 1953–54, **19,** 262; Mishra, *Proc. Bihar Acad. agric. Sci.*, 1955, **4,** 150; *Annu. Rep. Dep. Agric. Punjab*, 1949–50, 54; 1951–52, 56).

Loose smut induced by *Ustilago nuda* (Jens.) Rostr. is not so common in India as covered smut. It is sometimes serious in humid areas, like Gurdaspur, Kangra and Ambala districts in Punjab. Infection usually starts with flowers and grains are replaced by loose spore masses. The spores are air-borne and affect neighbouring ears. The fungus remains dormant inside the grains till they germinate. Thus loose smut is an internally seed-borne disease and seed treatment with surface disinfectants is of no value in controlling the disease. Hot water treatment of seeds is effective; seeds are soaked for 4–6 hr. in cold water and then immersed in hot water at 126°F. for 15 minutes. A simpler and equally effective method is solar heat treatment; seeds soaked in water for 4 hr. are exposed to sun for 7 hr. on a brick floor; the method is effective when the shade temperature exceeds 100°F. during summer months. In peninsular India, where shade temperatures rarely exceed 100°F., a variant of this treatment is reported to have proved effective; soaked seeds are spread out in a thin layer on galvanized iron sheets and exposed to the midday sun for 1½–2 hr., the seeds being stirred once or twice to bring them into effective contact with the hot sheet. Soaking of seeds in water for 6 hr. followed by soaking in a 0.2% solution of Spergon for 40 hr. before planting is also reported to be effective (Butler, 185; Milne *et al.*, 238–39; Vasudeva & Iyengar, *Curr. Sci.*, 1950, **19,** 218; Tyner, *Sci. Agric.*, 1951, **31,** 187; Patel *et al.*, *Curr. Sci.*, 1950, **19,** 324).

Barley, like wheat, is susceptible to black or stem rust caused by *Puccinia graminis* Pers. and yellow or stripe rust caused by *P. glumarum* (Schm.) Erikss. & Henn. These rusts are not transmissible to wheat from barley, but they are sometimes transmitted from wheat to barley. Barley yellow rust is relatively rare in the plains of peninsular India. Brown or dwarf rust, caused by *P. anomala* Rostr., is very rare in this country. Leaf rust of wheat, caused by *P. triticina* Erikss., is reported to attack seedlings of certain types of cultivated barley under experimental conditions; older plants are resistant. Compared to wheat, the damage to barley by rusts is less severe as the crop matures earlier.

Black rust infection may start from self-sown plants, as also from summer crops in hilly areas, Himalayas in the north and Nilgiri and Pulney hills in the south, whence spores are carried by wind and infect winter crops grown in the plains. Total suspension of barley and wheat cultivation for 5 years in the hills and cultivation of alternative crops such as rye have been suggested for checking infection. The most effective method of checking rusts is the breeding of rust-resisting types of barley and wheat: this is a tremendous task in view of the existence of several physiologic races of rusts. Sulphur dusting provides a prophylactic measure for preventing the germination of uredospores, but the cost is prohibitive. Application of nitrogenous fertilizers tends to increase the susceptibility of barley to rust; application of phosphate has the opposite effect. The severity of infection may be lessened by reducing the dose of nitrogenous fertilizer (Wlth India—Raw Materials, IV, 76; Mundkur, 161–64; Mehta, *Sci. Monogr. Indian Coun. agric. Res.*, No. 18, 1952; *Proc. 7th Meeting, Crops & Soils Wing, Bd Agric. Anim. Husb. India*, 1950, 29–40; Prasada, *J. Indian bot. Soc.*, 1947, **26,** 213).

Powdery mildew, caused by *Erysiphe graminis*

DC. var. *hordei* Marchal, is prevalent in the sub-montane districts of North India but is not of importance in the plains. The leaves are usually affected; under certain conditions, sheaths, stems and glumes may also be affected. The plants become stunted and leaves become deformed and may be shed. Sulphur dusting affords control but the cost is prohibitive (Wlth India—Raw Materials, IV, 72; Mundkur, 119–21).

Three species of *Helminthosporium* are reported to attack barley in India. *H. sativum* P.K. & B. infects seedlings and causes root and stem rot. The infection may spread to older plants and extend to aerial parts including flowers. Large brown or reddish patches are formed on leaves, which curl up and dry. The organism can live in the soil as well as in and upon infected grains. Barley grown year after year on the same plot is the worst affected, both during seedling and mature stages. There are several strains of this fungus, but the most common ones are those on barley and wheat, and they are capable of infecting either of the two hosts as well as several other grasses. Seed treatment with mercuric compounds, like Uspulun and Ceresan, have been reported to control the disease, but it cannot be checked entirely by this means, as infection may occur during the growing season. Differential varietal resistance to the pathogen has been observed among Indian barley types and breeding of resistant types offers the most promising method of control (Mitra & Bose, *Indian J. agric. Sci.*, 1935, **5**, 449; Wilson, 132, 147).

Leaf stripe disease, caused by *H. gramineum* Rabenh., is characterised by the appearance of straw-coloured longitudinal stripes on leaf blades which soon turn brown or reddish brown. Affected leaves dry up and ears may not emerge from sheaths or may become stunted with twisted and bent awns. Grains are shrivelled. Hot water treatment of seeds is reported to be effective in preventing disease manifestation. Certain types of barley, like *K. 12* and *KN. 292*, are resistant to the disease.

Net blotch, caused by *H. teres* Sacc., is harmful to certain types of barley introduced from outside. The leaf is discoloured and net-like patches appear on it (Mitra & Bose, loc. cit.; Wilson, 147; Mehta *et al.*, *Sci. & Cult.*, 1953–54, **19**, 152).

*Harvest and yield*—The crop becomes ready for harvest in about four months after sowing. The plants are either pulled out or cut with sickles and the sheaves stacked for about a week or more. The grains are threshed out by beating with sticks or trampling by oxen.

TABLE 5—AVERAGE YIELD (LB. PER ACRE) OF BARLEY IN DIFFERENT STATES

| State | 1952-53 | 1953-54 | 1954-55 | 1955-56 |
|---|---|---|---|---|
| Rajasthan | 1,185 | 980 | 949 | 1,023 |
| Punjab | 780 | 847 | 781 | 780 |
| Madhya Pradesh | 782 | 609 | 738 | 734 |
| Uttar Pradesh | 823 | 774 | 799 | 721 |
| Bihar | 448 | 426 | 478 | 521 |
| All-India | 805 | 746 | 774 | 748 |

TABLE 6—YIELD OF BARLEY (LB. PER ACRE) IN DIFFERENT COUNTRIES*

| | 1954-55 | 1955-56 |
|---|---|---|
| Denmark | 2,990 | 3,226 |
| United Kingdom | 2,442 | 2,867 |
| Western Germany | 2,330 | 2,386 |
| Japan | 2,274 | 2,162 |
| France | 1,826 | 1,803 |
| United States | 1,344 | 1,322 |
| Canada** | 1,075 | 1,221 |
| Argentina | 1,266 | 1,030 |
| Turkey** | 851 | 1,008 |
| Australia** | 874 | 1,008 |
| Iraq | 986 | 571 |
| Morocco | 776 | 560 |

* *Grain Crops*, Commonwealth Econ. Comm., 1957, Table 51.
** Yield per sown acre.

The yield of barley per acre is mainly influenced by soil, sowing time, moisture supply and the type of barley grown. Barley grown on poor soils or sown late in the season gives lower yields. Irrigated crops give as much as 47 to 132% more yield than unirrigated crops. The average yield (including irrigated and unirrigated crops) ranges from 468 lb. per acre in Bihar to 1034 lb. per acre in Rajasthan (Table 5). Under favourable conditions, some of the improved types of barley have yielded as much as 2,870 lb. per acre (*Rep. Marketing Barley*, 1945, 5; Shaw & Bose, *Agric. J. India*, 1929, **24**, 373; Roberts & Kartar Singh, 246).

The average yield of barley in India is exceptionally low as compared with that recorded in other countries (Table 6). The highest yield is obtained in the intensely cultivated areas of north-west Europe

and Japan, largely as a result of sowing improved strains and heavy application of fertilizer. In North America, where cultivation is extensive rather than intensive and droughty conditions prevail, the average yield is much lower than in Europe (*Grain Crops*, Commonwealth Econ. Comm., 1955, 70–71; Hunter, 35).

*Storage*—Barley, like wheat, is stored in godowns (in bulk or in bags) or in underground pits (in bulk). Losses in storage may occur due to dampness, vermin attack and weevil infestation. Barley stored in godowns is less susceptible to insect attack; also loss due to dampness is negligible in godowns with cement or stone-slab flooring (*Rep. Marketing Barley*, 1945, 23–24).

*Marketing*—Unlike wheat and rice, most of the barley grown in India is retained by cultivators for their own use. The percentage of retention by cultivators is 74% of the output in the case of barley, 55% in the case of wheat and 40.5% in the case of rice. The highest retention (89%) is in north and east Bihar where barley forms the main subsistence crop. Punjab barley being superior in quality and suitable for malting and pearling, a large part of the output is sent to the market.

The important marketing centres for barley in India are Misrikh, Hardoi, Shahjahanpur, Sitapur, Bulandshahr, Hapur, Farrukhabad, Agra, Mathura and Chandausi in Uttar Pradesh; Muzaffarpur, Khagaria and Lakhi Sarai, Bettiah, Chaprah, Nanguchia and Hilsa in Bihar; Abohar, Rewari, Farrukhnagar, Kalanwali, Bhatinda, Barnala, Sunam, Patiala, Mandi and Pataudi Road in Punjab.

Practically no grading is done in India and the material sold in the market is usually a mixture of different types grown in the area. In U.S.A., Canada, and other barley-producing areas in the west, the factors taken into account in grading are: admixture with other types of barley, bushel weight or 1,000 kernel weight, percentage of heat-damaged kernels, percentage of diseased kernels, foreign matter and broken kernels, and moisture content; percentage of germination is an additional factor taken into consideration in the grading of malting barleys. The bushel weights of Indian barleys (49–57 lb.) compare favourably with the figures prescribed in Canada for 6-rowed malting and feeding barleys (*Rep. Marketing Barley*, 1945, 27–28; Roberts & Kartar Singh, 250).

There is hardly any export of barley from India at present. During the period 1923/24–1928/29, the annual export averaged to 145,000 tons, the chief importing countries being U.K., Germany, Netherlands and Belgium. The export dropped to 12,200 tons (av.) per year during the next ten years and practically ceased when World War II broke out. Some quantities (about 85,000 tons per year valued at Rs. 28 lakhs) were imported during the period 1946/47–1948/49, mainly from Australia, Argentina and U.S.A. Imports have practically ceased since 1950–51.

*Price*—Prior to the outbreak of war, the average price of barley in different growing areas ranged between Rs. 2 and Rs. 2.62 per maund. The prices rose subsequently. The harvest and wholesale prices of barley in selected centres in India are given in Tables 7 & 8.

TABLE 7—HARVEST PRICE OF BARLEY

(price per md. in Rs.as.ps.)

| Year | U.P. | Punjab | Bihar | Rajasthan | Himachal Pradesh |
|---|---|---|---|---|---|
| 1938-39 | 2- 6-0 | 1-15-0 | 2- 6-0 | n.a. | 1- 7-0 |
| 1942-43 | 7- 2-0 | 7- 4-0 | 6-15-0 | n.a. | n.a. |
| 1946-47 | 8-14-0 | 7- 4-0 | 9- 7-0 | n.a. | n.a. |
| 1950-51 | 11- 2-6 | 9- 1-0 | 19- 9-6 | 14-0-0 | 13- 8-0 |
| 1951–52 | 10-11-0 | 10- 5-6 | 15- 0-0 | 13-0-0 | 10- 8-0 |
| 1952-53 | 11- 0-0* | 10- 5-0 | 13- 7-0 | 10-8-0 | 14- 2-9 |
| 1953-54 | (*a*) | 8- 5-0 | 10-11-6 | 7-8-0** | 10-14-3 |

* Procurement price up to 19-6-52.
** Maximum procurement price.
(*a*) Decontrolled.
n.a. not available.

TABLE 8—WHOLESALE PRICE OF BARLEY

(price per md. in Rs.as.ps.)

| Year | U.P. (Kanpur) | Punjab (Ludhiana) | Bihar (Patna) | Rajasthan (Jaipur) | Himachal Pradesh |
|---|---|---|---|---|---|
| 1939 | 2-9- 8 | 2- 5-11 | 2- 9-3 | n.a. | 7-4-0 |
| 1942 | 6-1- 6 | 3-10- 3 | 4-15-2 | n.a. | n.a. |
| 1946 | 12-2- 3 | 5- 6- 2 | 8- 2-8 | n.a. | n.a. |
| 1950 | 9-8-10* | 8-11- 6 | 18-14-0 | 10-12-0 | n.a. |
| 1951 | 9-9- 7* | 8-12- 0** | 20-10-7 | 11-10-3 | 13-0-0 |
| 1952 | 9-9- 7* | 8-10- 4** | 17- 4-8 | 14- 5-4† | 13-6-0 |
| 1953 | 13-1- 3 | 11- 1- 8 | 13-13-2 | 14- 5-4† | 13-0-0 |
| 1954 | 9-0- 3 | 8-11- 0 | 10- 2-3 | n.a. | 12-0-0 |
| 1955§ | 6-9- 0 | 6- 7- 0 | 8- 8-0 | 7-13-0 | n.a. |
| 1956§ | 6-4- 0 | 8- 1- 0 | 8-13-0 | 7-10-0 | n.a. |

* Wholesale ration rate. ** Monopoly procurement rate.
† Retail price. § Prices at Hapur (U.P.), Moga (Punjab) & Motihari (Bihar). n.a. not available.

UTILISATION

The bulk of barley is ground to flour for local consumption. The flour is generally mixed with wheat and gram flour for preparing *chapatis;* it is seldom used alone. A fairly large quantity of barley is used in the form of *sattu*, which is made from both ripe and unripe grains, by roasting and grinding into a meal. *Sattu* is taken as a cooling drink, particularly in western U.P., Punjab and Rajasthan ; it is also eaten by the poorer classes in Bihar and U.P. High grade barley is used in malting, pearling and preparation of infant foods. Low grade barley is used as feed for livestock. The average annual consumption of barley in India for various purposes has been estimated as follows: flour, 64 ; *sattu*, 12 ; livestock feeding, 22 ; malting and pearling, 1%. In Europe and America, barley is used mainly as a feed grain ; comparatively small quantities are used for malting and pearling (*Rep. Marketing Barley*, 1945, 13–15, 59 : Blanck, 429).

Barley grain is demulcent and easily assimilable ; it is therefore used in the dietary of invalids and convalescents. Pearl barley is the form in which it is commonly employed. Powdered parched grains are used in the form of a gruel for painful and atonic dyspepsia. A decoction of barley, barley water as it is called, is a mucilaginous drink useful in cases requiring demulcent treatment ; it is given in feverish disorders, inflammation of the membranes of the chest, diarrhoea, and catarrhal disorders of bowels. It is especially valued in infant feeding as it prevents the formation of large milk curds. Barley water, with honey, is prescribed for bronchial coughs and, in conjunction with gum arabic, it is used for soothing irritation of the bladder and urinary passages. In Patna, the ashes of the leaf are used in the preparation of cooling sherbets. In Punjab, the ashes of stalks are given for indigestion (Caius, *J. Bombay nat. Hist. Soc.*, 1935-36, **38,** 562 ; Wren, 27 ; Kirt. & Basu, IV, 2703 ; U.S.D., 1955, 1713 ; Youngken, 146).

*Chemical composition*—The average composition of Indian barley is as follows: moisture, 12.5 ; protein, 11.5 ; ether extr., 1.3 ; mineral matter, 1.5 ; fibre, 3.9 ; carbohydrates, 69.3 ; calcium, 0.03 ; and phosphorus, 0.23% ; iron, 3.7 mg./100 g. The composition of different types of barley is influenced by the conditions of cultivation. The ranges of values for different constituents are as follows (dry basis): nitrogenous matter, 7–14 ; ether extr., 2–3 ; starch, 60-68; pentosans, 8-12 ; cellulose, 4–5 ; lignin, 4 ; sucrose, 1.5–2.5 ; invert sugar, 0.1–0.5 ; pectin, 0.5–1.0 ; and ash, 2–3%. The main variations are in starch and protein contents which vary inversely with one another. High protein barleys are generally valued for food and feeding, and starchy barleys for malting (*Hlth Bull.*, No. 23, 1951, 28 ; Thorpe, I, 647).

Two-rowed barleys contain more starch than six-rowed types. Barley starch closely resembles wheat starch and is a mixture of amylose (19%) and amylopectin. The free sugars present in barley are sucrose and raffinose, with smaller amounts of glucose, fructose, maltose, glucodifructose, and fructosans. The sucrose is located mainly in the germ. The pentosans present are urono-xylan, urono-araban, and possibly galacto-xylan (Thorpe, I, 647 ; MacWilliam & Percival, *J. chem. Soc.*, 1951, 2259 ; *Chem. Abstr.*, 1954, **48,** 5290).

The protein content of barley varies with the type and the protein content of a given type is influenced by soil and climatic conditions. Types grown during the hot dry weather mature rapidly and produce grain of high protein content ; those grown in mild humid climates mature slowly and yield grain with low protein content. Within a given climatic zone, high rainfall or irrigated conditions lower the protein content and increase the yield. As compared to the influence of environment, the varietal effect on protein content is not so marked (Jacobs, II, 1052).

Barley contains four classes of protein, viz. albumin, globulin, prolamin (hordein), and glutelin (hordenin) ; free amino acids and protein intermediates are also present. The proportions of different proteins present in the grain (total protein, 10.75%) are as follows: albumin, 0.3 ; globulin (including proteose), 1.95 ; hordein, 4.0 ; and hordenin, 4.5%. Recent studies have shown that each of these fractions consists of more than one protein. At least four distinct barley globulins, α-, β-, γ- and δ-globulins, have been recognised. Hordein, which resembles zein, is a complex. Table 9 gives the amino acid make-up of barley proteins (Winton & Winton, I, 280 ; Pool & Shooter, *J. Sci. Fd Agric.*, 1955, **6,** 514, 524, 534 ; Folkes & Yemm, *Biochem. J.*, 1956, **62,** 4).

The biological value of the total proteins of barley is reported to be 64 as compared to 67 of wheat protein. The essential amino acid make-up of total barley proteins (calculated to 16.0 g. N) is as follows: arginine, 4.5 ; histidine, 1.8 ; lysine, 2.4 ; tryptophan, 1.1 ; leucine, 5.5 ; *iso*leucine, 3.8 ; valine, 5.1 ; phenylalanine, 5.7 ; threonine, 3.6 ; and methionine, 1.0 g. The limiting amino acid is probably lysine

TABLE 9—AMINO ACID COMPOSITION OF BARLEY PROTEINS*

(% N of protein nitrogen)

| | Albumin | Globulin | Hordein | Hordenin |
|---|---|---|---|---|
| Arginine | 13.0 | 22.0 | 6.0 | 12.0 |
| Histidine | 4.3 | 3.1 | 2.2 | 4.3 |
| Lysine | 7.9 | 6.3 | 0.8 | 4.8 |
| Tyrosine | 2.7 | 1.5 | 1.6 | 1.9 |
| Tryptophan | 1.3 | 0.65 | 0.7 | 1.1 |
| Phenylalanine | 3.0 | 2.1 | 3.6 | 2.7 |
| Cystine | 1.5 | 2.6 | 1.5 | 0.9 |
| Methionine | 1.4 | 0.9 | 0.75 | 1.1 |
| Threonine | 3.4 | 2.4 | 1.9 | 3.1 |
| Leucine | 5.7 | 4.5 | 4.6 | 5.8 |
| Isoleucine | 4.1 | 2.2 | 3.6 | 3.5 |
| Valine | 5.8 | 4.1 | 3.5 | 4.9 |
| Glycine | 6.7 | 10.7 | 1.7 | 5.2 |

* Folkes & Yemm, *Biochem. J.*, 1956, **62,** 4.

(Block & Mitchell, *Nutr. Abstr. Rev.*, 1946-47, **16,** 263; Jacobs, I, 205, 207).

Barley fat has the following constants: sp. gr.$^{15°}_{4°}$, 0.9547; sap. val., 188.4; iod. val., 113.5; R.M. val., 0.87; Polenske val., 0.35; ester val., 159.4; acid val., 29.0; and unsapon. matter, 5.4%. The component fatty acids of the oil are: stearic, 2.6; palmitic, 7.4; oleic, 26.5; linoleic, 43.7; and linolenic, 0.44%. Barley contains 0.16% of phosphatides (mostly lecithin) with the following characteristics: P:N ratio, 1:1.01 and fatty acids, 69.1%; solid acids (mainly palmitic) constitute 14.8% of the total fatty acids and liquid acids (mainly linoleic), 84.6% (Winton & Winton, I, 284; Wittcoff, 233; Hilditch, 1956, 253).

The mineral constituents of barley grain are (dry basis): $K_2O$, 0.6–0.9; $Na_2O$, 0.1–0.3; CaO, 0.07–0.15; MgO, 0.2; $P_2O_5$, 0.8–1.2; S, 0.02; and $SiO_2$, 0.5–0.9%; trace elements: Al, 0.7; Fe, 4–9; Mn, 12; Cu, 0.2–0.6; and Zn, 2–3 mg./100 g. The iodine content of fresh Indian barley is reported to be 18 µg./kg. Fresh barley contains: vit. A (71 i.u./100 g.), thiamine (500–650 µg./100 g.), and riboflavin (90–140 µg./100 g.). Other vitamins present are: niacin (av., 7 mg./100 g.), choline (96–125 mg./100 g.), pantothenic acid (395–620 µg./100 g.), folic acid, vit. D, and vit. E (1.7–2.1 mg./100 g.). The vitamin E potency is lower than the total tocopherol content because of the presence of the less active β-compound in appreciable proportion (total tocopherols, 5.6–7.1 mg./100 g.; α-tocopherol, 10%; β-tocopherol, 67%). Barley also contains: phytin (1.2%) located mostly in the husk, small amounts of nucleic and phosphoric acids, and porphyrin. The husk probably contains tannins (Thorpe, I, 648; Iodine Content of Foods, 58; Sherman, 690; Nelson, 167; *Chem. Abstr.*, 1954, **48,** 9485; Brown, *J. Sci. Fd Agric.*, 1953, **4,** 161).

Raw barley contains diastase, oxidases, catalase, peroxidase, phytase, lichenase, cytases, mannase, cellobiase, and mannobiase. Active proteolytic enzymes appear only at the time of germination: raw barley contains pro-enzymes (Thorpe, I, 648; Wehmer, I, 86–87; Encyclopaedia Britannica, XIV, 733).

*Pearl barley*—Barley grains from which the hulls and outer layers have been removed by a process of gradual abrasion are known in the trade as Pearl Barley. Well-filled and uniformly sized grains are selected for processing. The bran and the alleurone layer are first removed to give Pot Barley; further abrasion removes a major part of the embryo and yields hard round grains or pearls. Hundred lb. of barley yield 65 lb. of pot barley and 35 lb. of pearl barley (Kirk & Othmer, III, 601-2).

The chemical requirements of pearl barley and barley powder are given in Table 10. It contains (av.): thiamine, 50 µg.; riboflavin, 10 µg.; and nicotinic acid, 3 mg./100 g. The mineral constituents present are: calcium, 0.02; phosphorus, 0.181%; iron, 20.0 mg./kg.; and copper, 4.0 mg./kg. Pearl barley does not contain any hordein. The essential amino acids present are (dry basis): valine, 0.60; leucine, 0.89; *iso*leucine, 0.53; threonine, 0.42; methionine, 0.12; lysine, 0.28; phenylalanine, 0.68; tryptophan, 0.13; histidine, 0.21; and arginine, 0.53%. The absorption ratios of the different constituents of pearl barley, as determined by trials on human subjects are: protein, 81.15±4.95; fat, 66.82±4.86; carbohydrates, 98.36±1.29; fibre, 46.6±4.80; and ash, 78.32±2.13% (Nutritional Charts, 24; Jacobs, II, 1057; U.S.D., 1955, 1713; *Chem. Abstr.*, 1954, **48,** 9498).

*Flour*—Barley flour is produced by milling the grains; it is also a by-product in pearl barley manufacture. A flour of good quality is obtained by milling pearl barley. In India, large quantities of barley are ground in stone *chakkis*; only small quantities are milled. Barley flour is generally regarded as inferior to wheat flour for human consumption. The digestibility coefficient of pressed barley is higher than that of pressed wheat. Barley flour is unsuitable for use alone in bread making as it contains little or

no gluten, and the dough does not 'rise'; it can be used as an addition to wheat flour (up to 10–15%) for bread making without appreciably affecting the taste of bread; it can be mixed, up to 15–25%, with wheat flour for making *chapati*. In some flour mills, a mixture of barley and wheat in the required proportion is ground to give a flour (Kirk & Othmer, III, 602; Roberts & Kartar Singh, 252; *Chem. Abstr.*, 1954, **48,** 10152).

Prior to World War II, India was annually importing approximately 1,000 tons of pearl barley and barley powder; recent data relating to imports are not available. The imported product fetches better price, mainly due to the uniformity of grains (*Rep. Marketing Barley*, 1945, 11).

*Feed* Barley is fed to stock either alone or mixed with other grains. It is usually crushed or ground to meal and mixed with other feedstuffs to give a balanced ration. It is relished by most stock, and is considered particularly useful for pigs and horses. In India, barley is fed to horses and to some extent to cattle. The digestible nutrients present in barley (from Mona, Punjab) are as follows (dry basis): crude protein, 8.97; carbohydrates, 77.55; ether extr., 0.83; and total, 86.38 lb./100 lb. Barley is considered equal to maize in nutritive value. Feeding trials carried out in Lyallpur show that hard barley contains a higher proportion of digestible protein than oats (4.4%) and has a nutritive ratio of 9.7 compared with 14.1 for oats (Lander, 192, 387, 447; Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 29).

Barley plant is fed green or as hay. In some parts of India, stalks are cut 2 or 3 times without marked injury to grain yield. For making hay, the plant is cut while still green after the heads are well formed: the partially matured grain which is rich in protein adds to the feeding value of the hay. The dry stalks and leaves obtained during threshing are also useful as cattle feed. Table 11 summarises the chemical compositions of green feed, stalks, straw and heads (Shands & Dickson, *Econ. Bot.*, 1953, **7,** 3).

TABLE 10—CHEMICAL REQUIREMENTS OF PEARL BARLEY AND BARLEY POWDER*
(per cent)

| | |
|---|---|
| Moisture, *max.* | 12.5 |
| Total ash (dry basis), *max.* | 1.0 |
| Acid insol. ash (dry basis), *max.* | 0.05 |
| Protein (dry basis), *min.* | 7.0 |
| Crude fibre (dry basis), *max.* | 0.50 |
| Alcoholic acidity (as $H_2SO_4$), with 90% alcohol, *max.* | 0.10 |

* IS: 1156 1957; IS: 1157 1957.

TABLE 11—FEEDING VALUE OF BARLEY*
(% dry wt.)

| | Crude protein | Fibre | N-free extr. | Ether extr. | Total ash | CaO | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|---|---|---|
| Green feed | 11.47 | 31.85 | 43.45 | 1.86 | 11.37 | 0.72 | 0.59 | 3.98 |
| Stalks | 2.97 | 38.59 | 51.32 | 1.04 | 6.08 | 0.46 | 0.19 | 1.58 |
| Straw | 2.21 | 47.39 | 41.43 | 0.92 | 8.05 | 0.44 | 0.16 | 2.71 |
| Barley heads | 9.89 | 20.21 | 64.00 | 1.11 | 4.79 | 0.40 | 0.42 | 1.07 |
| Grain | 11.50 | 5.39 | 78.84 | 1.06 | 3.21 | 0.25 | 0.85 | 0.56 |

* Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 12, 20.

The straw is used as a roughage for livestock or as bedding. It is also employed in making hats and for packing. The straw equals oat straw in nutritive value but is regarded as inferior to wheat straw; it is liable to cause colic due to its being bearded and spiny. Barley straw is suitable for the manufacture of cellulose pulp; it contains: cellulose, 48.6; lignin, 16.4; and pentosan, 31.9%. It yields 14.3% furfural (Lander, 164; Brady, 75; Mukerji, 192; Grant, *Fibres*, 1953, **14,** 285; Subba Rao, *Indian Soap J.*, 1952–53, **18,** 90).

### BARLEY MALT

Malt is the product obtained by the processing of germinated grains, e.g. barley, wheat, oats, ragi or jowar. In commerce, the term malt is generally applied to barley malt; malts from other grains are designated as wheat malt, oat malt, ragi malt or jowar malt.

The principal purpose of malting is to activate the enzyme systems of the resting grain, mainly amylolytic and proteolytic systems, and to bring about certain desired physical and chemical changes in the kernel. The grains are steeped in water and germinated under controlled conditions until the required "modification" is effected. Germination is stopped by drying and the germinated grain is then heat-cured in kilns until the desired colour and flavour are developed. The essential steps in the production of malt are: selection of grain, grading and storage, steeping, germination and kilning. Two types of malts are prepared, depending upon their end use, namely, brewers' malt and distillers' malt.

*Selection*—Only the finest quality of barley with high germinative capacity is used for malting. The malting quality is usually judged by the appearance of the grain. High class malting barley is uniform and plumpy with a bright yellow colour; the skin is finely reticulated as evidence of complete ripeness, and blackened ends or musty smell are absent.

Brewers generally prefer barley with low nitrogen content and high grain weight. The weight of 1,000 grains of good malting barley should not be less than 30 g.; one in which the weight of 1,000 grains is 50 g. is considered excellent. Among barleys of the same type and origin, those with low nitrogen content are superior. Barleys used for beer making in different countries contain 1.2 to 2.0% nitrogen (British, 1.2–1.5; Continental, 1.6–1.7; and American 1.8–2.0%). Punjab barley used in Indian breweries contains 1.8% nitrogen.

In general, 2-rowed barleys contain relatively low nitrogen and the amylolytic activity of malts derived from them is less than that of malts from 6-rowed varieties. Most beers in Europe are brewed with malt as the source of both amylase and starch and 2-rowed barleys are preferred for this purpose by brewers. On the other hand, in U.S.A. rice and corn are added to malt while brewing and for this reason, a malt with high amylolytic activity, such as that derived from 6-rowed Manchurian barley, is employed. In India, beer is brewed almost entirely from malt derived from 6-rowed types. For distilled liquors, malts with high amylase activity, i.e. those derived from barleys of high nitrogen content, are in demand. Malts of high diastatic activity are also used in bakeries and in the manufacture of desizing agents required in the textile industry.

*Grading and storing*—Selected barley is screened to remove broken and immature grains and foreign matter, graded according to size, dried and stored. Barley with high moisture content (14% or more) deteriorates during storage. It is therefore necessary to reduce the moisture level by kiln drying at 100–120°F. Dried grains are stored for 6–8 weeks.

*Steeping*—Stored grains are steeped in water (at 50–60°F.) for 48–70 hr. with frequent changes of water and intermittent aeration. A small quantity of lime water is sometimes added to the first steep water as it improves the appearance of the finished product. The steep water is drained out and the grain (moisture content, 44–45%) germinated under controlled conditions of temperature, humidity and aeration.

*Germination*—The steeped grain is heaped, or couched, on the germinating floor in a deep layer. Couching raises the temperature in the heap sufficiently high to initiate the germination. After a few hours, the couch is broken and the grain spread to a depth of a few inches and a temperature of 55–60°F. is maintained during germination. The loss of moisture is replenished by sprinkling water. The malt is turned over at intervals to keep the moisture and temperature uniform, to aerate the grain and allow the carbon dioxide to escape. The germination is arrested after 7–8 days when rootlets develop and the acrospire or plumule grows under the hull of the grain.

*Kilning*—The green malt is air-dried for 1–2 days by stacking in a heap and thereafter kiln-dried to arrest further germination without destroying the enzymic activity. The moisture content is brought down to about 6% by gradually raising the temperature to 150°F. during 2–3 days and then rapidly to 190–215°, according to the purpose for which the malt is required. Thus for pale ale, the temperature is raised to 190–95°F. and maintained at that temperature for 6–8 hr.; the temperature is a little higher (205–15°F.) when the malt is required for brewing port and stout. The malt so obtained has the desired flavour and aroma, and the moisture content is reduced to about 4%. The malt is stored, after removing the rootlets, in air-tight containers. Storing for 2–4 months improves the quality of malt for brewing purposes. The characteristics of brewers' malts are summarised in Table 12.

For the production of distillers' malt, the seeds are germinated at a relatively high moisture level and dried under milder conditions, the object being to obtain a malt of high amylase activity. Distillers'

TABLE 12—CHARACTERISTICS OF BREWERS' MALTS*

| | British malts | | | |
|---|---|---|---|---|
| | Pale malt | Mild ale malt | Amber malt | Californian malt |
| Moisture (%) | 2.4 | 2.5 | 2.0 | 2.0 |
| Extract (lb./336 lb.) | 97 | 96 | 94 | 88 |
| Diastatic power (Lintner) | 35 | 25 | 14 | 34 |
| Colour (degree) | 4 | 7 | 20 | 3 |
| Cold water extr. (%) | 20 | 20 | 21 | 17 |

* Allen, I, 182.

malt has comparatively less flavour and aroma than brewers' malt. Special malts, e.g. high-dried, dextrin, caramel, and black malts, are prepared for specific uses. They are characterised by intense flavour and colour and are obtained by germinating steeped grain at relatively high moisture levels and kilning at high temperatures.

*Chemical changes during malting*—The chemical changes in the grain during malting are brought about by several enzymes, such as the cytases, proteases and amylases, elaborated or activated during germination, primarily in the epithelial layer of the scutellum. Table 13 shows the changes in composition of barley grain due to malting. The total loss in weight, as a result of the malting process, is 15-25%.

The cytases, consisting of several enzymes, are activated early during the germination. They act on cell walls and render the endosperm permeable to other enzymes. Pentosans or pentoses are rendered soluble by the action of cytases and an increase in these compounds is an index of the degree of modification.

The proteolytic enzymes appear only during germination and include a proteinase and at least two peptidases. They act on the protein matter of the grain and solubilize 25-30% of the total protein. The soluble products—amino acids, peptides, etc.—furnish the nutrients for yeast during brewing; they are also responsible for giving body, foam retention properties, and character to the beer.

The amylolytic system comprises two major enzymes, namely, $\alpha$- and $\beta$-amylases. During germination, most of the $\beta$-amylase which occurs in a bound form in the raw grain is liberated and the $\alpha$-amylase is elaborated. The amylases diffuse from the scutellum into the endosperm and hydrolyse a part of the starch to soluble sugars. Only 8–10% of the starch is converted into fermentable sugars during malting; the major part of the conversion takes pace during the mashing process.

TABLE 13—COMPOSITION OF TYPICAL BARLEYS & MALTS*

(% dry matter)

| | Two rowed barley | | Six-rowed barley | |
|---|---|---|---|---|
| | Barley | Malt | Barley | Malt |
| Starch | 61.05 | 55.16 | 54.05 | 50.65 |
| Proteins, insol. | 4.74 | 6.06(?) | 6.96 | 5.25 |
| Proteins, sol. | 2.53 | 4.01 | 2.14 | 3.47 |
| Reducing sugars | 0.96 | 3.40 | 0.67 | 3.84 |
| Sucrose | 1.09 | 6.40 | 2.31 | 7.18 |
| Fat | 2.51 | 1.99 | 1.99 | 1.94 |
| Fibre | 4.99 | 5.71 | 7.86 | 8.41 |
| Ash | 2.82 | 2.65 | 2.76 | 2.46 |

* Allen, I, 172.

Other enzyme systems involved in the malting process are desmolases, carbohydrases, esterases including lipase and phosphatase, and oxidases including peroxidase, phenolase and catalase (Thorpe, II, 87–91 ; Kirk & Othmer, VIII, 705–15 ; Tauber, 63, 327–34 ; Hunter, *World Crops*, 1950, **2,** 407 ; Wright, ibid., 1950, **2,** 451 ; Bishop, ibid., 1950, **2,** 492 ; Roberts & Kartar Singh, 251 ; Thomson, *Chem. & Ind.*, 1953, 112 ; Preece, ibid., 1953, 160 ; Shands & Dickson, *Econ. Bot.*, 1953, **7,** 3 ; 1954, **8,** 106).

*Uses*—About 80% of the malt produced in U.S.A. is utilised for beer manufacture : a small portion is utilised for the manufacture of industrial alcohol and whisky. Other uses of malt include: textile desizing agents, pharmaceutical preparations, breakfast cereals, malted milk concentrates, infant foods, bakery products and candies. Malt flour is used as an amylolytic supplement in wheat flour milling. In India, malt is utilised almost entirely for the production of beer and whisky (Kirk & Othmer, VIII, 716–17 ; Blanck, 432 ; *Rep. Marketing Barley*, 1945, 12 ; Wlth India—Industrial Products, I, 136).

Malt extract, prepared by mashing malt and concentrating the mash liquor to a syrup, has nutritive and laxative properties. It contains maltose (45-55%) with small quantities of dextrin, glucose and other carbohydrates, proteins and amylolytic enzymes. Malt extract is easily assimilable and is prescribed as a restorative in debilities of all kinds, particularly when the digestion is weak. In certain types of dyspepsia, it is employed to increase the digestion of starches. Malt extract is used as a vehicle for the administration of liver oils, cascara sagrada, creosote and salts of iron. Dry malt extract possessing high diastatic power is an ingredient of many dry pharmaceutical preparations (B.P.C., 1949, 339 ; U.S.D., 1955, 781 ; Martindale, I, 695).

Special malts are used primarily for their colour and flavour. They possess little amylase activity, but contain considerable amounts of dextrins and sugars. They are used as additions to brewers' malt in the manufacture of dark beers. They are used in coffee substitutes and other flavoured products (Kirk & Othmer, VIII, 717).

The by-products of the malt industry are of minor importance. Screenings and kernels too small for malting are used as feed. Barley rootlets (malt sprouts), forming 3–5% of the weight of grain, are rich in proteins and are used in dairy feeds; they are used to a limited extent as a medium in industrial fermentations. The rootlets contain (av. values): moisture, 7.06; proteins, 27.17; fat, 2.40; and fibre, 11.89%. Deteriorated sprouts are used as fertilizer; they contain: nitrogen, 4–5; phosphorus ($P_2O_5$), 1–2; and potash, 2–2.5% (Kirk & Othmer, VIII, 714; Winton & Winton, I, 291; Bruttini, 234).

*Indian industry*—Malt is produced by breweries in India primarily for making beer and whisky; small quantities are sold to bakeries. Malt extract and other malt products are not manufactured on a commercial scale. Data relating to the quantity of barley consumed in the Indian brewery industry at present are not available. It is stated that the annual requirements of Solan Brewery in Simla Hills vary from 30,000 to 40,000 md. of barley obtained mostly from Gurgaon and Ferozepore districts in Punjab (*Rep. Marketing Barley*, 1945, 12, 33; Information from Messrs *Dyer Meakin Breweries Ltd.*, Solan).

Indian breweries have long been using barley from the south-eastern districts of Punjab; this being regarded as the only suitable Indian barley for malting. Recent investigations have shown that malting types are grown in other areas in India, especially in U.P. The nitrogen content of U.P. barleys varies from 1.30 to 1.47%. A large number of Punjab barleys have been tested at the Institute of Brewing, London; the malts obtained from some of the 2-rowed barleys, have been found to be comparable to the best English malts. Also, the majority of 6-rowed barleys were found suitable for malting; they gave high values for brewers' extract and low malting loss. Table 14 summarises the composition of Punjab barleys and malts (*Rep. Marketing Barley*, 1945, 9; Maya Das, *Indian Fmg*, 1942, 3, 498; *Indian J. agric. Sci.*, 1932, **2**, 86).

TABLE 14—COMPOSITION OF PUNJAB BARLEY & MALT*

| | Two-rowed barley | Six-rowed barley |
|---|---|---|
| BARLEY: | | |
| Moisture (%) | 10.1–10.8 | 10.0–10.8 |
| 1,000 grain wt. (g.) | 35.6–53.2 | 26.3–44.7 |
| Nitrogen (% on dry wt.) | 1.551–1.910 | 1.175–2.075 |
| MALT: | | |
| Moisture (%) | 1.48–2.16 | 1.64–2.26 |
| Extract (lb./quarter of 336 lb.) | 96.5–100.8 | 87.4–100.9 |
| Diastatic power (Lintner) | 31.5–54.5 | 17.5–59.0 |
| Colour | 4.0–8.0 | 3.5–11.5 |
| Cold water extr. (%) | 17.1–20.7 | 17.2–29.7 |
| Soluble nitrogen (% on dry wt.) | 0.488–0.569 | 0.345–0.667 |

* *Indian J. agric. Sci.*, 1932, **2**, 86.

**Hornstone** — *see* **Quartz**

**Horse Bean** — *see* **Canavalia**

**Horsegram** — *see* **Dolichos**

**Horseradish** — *see* **Cochlearia**

**Horseradish Tree** — *see* **Moringa**

**Horses** — *see* **Livestock**

**Horsetails** — *see* **Equisetum**

**HORSFIELDIA** Willd. (*Myristicaceae*)

A large genus of trees distributed in tropical Asia and New Guinea. Three species are recorded in India.

**H. amygdalina** (Wall.) Warb. syn. *Myristica amygdalina* Wall.

Fl. Br. Ind., V, 106; King, *Ann. R. bot. Gdns Calcutta*, 1891, **3**, 300, Pl. 128.

KHASI *Dieng-soh-jodao, dieng-ja-lyntep*; GARO —*Bolchok-pok*; MIKIR—*Dettakarong, pran-dangarong*; NAGA—*Ching-liang-pai.*

A tall, glabrous tree, c. 65 ft. high, found in Sibsagar, Cachar, North Cachar hills, Lushai hills, Goalpara, Garo hills and the foot of Khasi hills. Leaves aromatic, 4.0–10.5 in. long and 1.0–4.0 in. broad, entire, elliptic to elliptic-lanceolate or obtuse, glabrous, shining above; flowers unisexual; fruits obscurely trigonous, ovoid, 1.3–2.0 in. long; seeds oblong-cylindric, 0.8 in. long with a thin, fleshy, yellowish aril. The seed and the aril are said to be eaten (Fl. Assam, IV, 44).

**H. irya** (Gaertn.) Warb. syn. *Myristica irya* Gaertn.

D.E.P., V, 314; Fl. Br. Ind., V, 109; King, *Ann. R. bot. Gdns Calcutta*, 1891, **3**, 308, Pl. 141.

ANDAMANS—*Chooglum, mutwinda.*

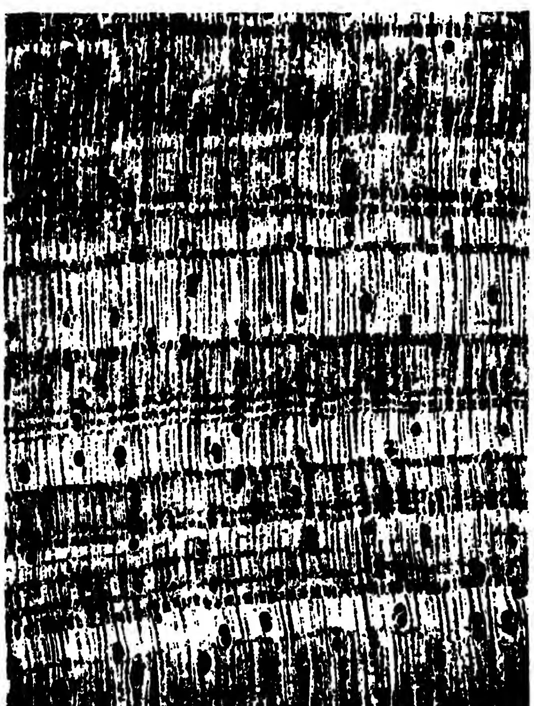
A tall evergreen tree, 60–100 ft. high and 4–8 ft. in girth, with greyish brown, somewhat flaky bark; leaves 4–15 in. long and 1.3–4.0 in. broad, lanceolate

or oblong-lanceolate; flowers fragrant, very small, yellowish, in axillary compound panicles; fruits almost globose, about 1 in. across with flame-red aril, completely enclosing the seed.

The tree is common in Andaman Islands in damp localities bordering mangrove creeks, but not in places reached by the sea. It is usually found in association with *Barringtonia racemosa* and *Calophyllum spectabile*. It flowers in December–February and fruits during the rainy season (Parkinson, 224).

The wood is light (wt., 37 lb./cu. ft.), straight-grained, even- and medium- coarse-textured, lustrous, light red to reddish brown or light brown in colour, and moderately durable under cover. It seasons readily, works well under tools and takes a good polish. The timber is often confused with that of *Terminalia manii*. When cut on the quarter, it presents a fair silver grain. It can be classed as a superior packing case wood. It was once used for tea boxes in Ceylon (Pearson & Brown, II, 818–20; Lewis, 322; Macmillan, 215).

The seeds contain an oleo-resin (*c.* 42% on dry wt.) which is reported to be used for making candles. A decoction of the bark is used by the Malays as a



*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 81. HORSFIELDIA IRYA—TRANSVERSE SECTION OF WOOD (× 10)

gargle for sore throat. The flowers may be used as perfume (Burkill, I, 1198).

**H. kingii** (Hook. f.) Warb. syn. *Myristica kingii* Hook. f.

Fl. Br. Ind., V, 106; King, *Ann. R. bot. Gdns Calcutta*, 1891, **3**, 300, Pl. 127.

ASSAM—*Amol*; LUSHAI—*Siltui*; GARO—*Bolong, bolouchi*; NEPAL—*Runchepot, ramguwa*; LEPCHA—*Kaoul-kung, donglukung*.

A tall tree, *c.* 60 ft. high, found in Sikkim Himalayas up to an elevation of 4,000 ft., throughout Assam except Khasi hills, and in northern Bengal. Leaves 6–10 in. long, elliptic-obovate or oblanceolate, glabrous; fruits 1.5 in. long, with aril completely enveloping the ovoid smooth seed. The fruit is edible, but is reported to cause intoxication. The seed is used as a substitute for arecanut. The bark on incision (just after the rains) yields a red juice in great abundance which is dried and used as a substitute for Malabar kino (from *Pterocarpus marsupium*). It contains 30.2% tannin and is considered useful for mouth sores (Cowan & Cowan, 105; Fl. Assam, IV, 43; Hooper, *Agric. Ledger*, 1900, No. 5, 46; 1902, No. 1, 49).

**HOUTTUYNIA** Thunb. (*Saururaceae*)

Fl. Br. Ind., V, 78; Fl. Malesiana, Ser. I, **4** (2), 47, Fig. 1.

A monotypic genus found in temperate regions, from the Himalayas to Indo-China, China, Formosa and Japan.

*H. cordata* Thunb., a perennial pungent herb, with copiously branching and creeping rootstock (up to 3 ft. long) and erect stems up to 3 ft. high, is found throughout the subtropical Himalayas, from Punjab to Sikkim and also in Assam, Khasi hills and Manipur up to 6,000 ft. It bears broadly ovate-cordate leaves and small naked flowers in spikes, subtended by four white petaloid bracts.

*H. cordata* is a hardy plant growing in shallow water or moist loamy soil along ditches. It can be propagated by division or from seed. The seeds are parthenogenetically developed (Chittenden, II, 1015).

In Assam, China and Japan, the rhizome is reported to be eaten as vegetable, raw or cooked. In Japan, the rhizomes are dug out in September-October, dried in shade and stored in air-tight boxes after removing dust and fibrous rootlets. They are said to be sweet and are eaten after cooking with rice, sweet potato or beans. They are also reported to be used in

medicinal preparations prescribed for certain diseases of women. They are given to horses during the breeding season. In Indo-China, the entire plant is considered cooling, resolvent and emmenagogue. The leaves are recommended for measles, dysentery and gonorrhoea, and used in the treatment of eye troubles, skin diseases and hemorrhoids. In China, the plant is considered useful for indigestion ; it is applied as a plaster on injured parts to promote bone growth. The root extract is reported to possess diuretic action, attributable to the presence of quercitrin and inorganic salts, like potassium chloride and potassium sulphate. An active principle effective in the treatment of stomach ulcers has also been isolated from the plant. A sterol, resembling sitosterol and isolated from the rhizomes, stimulated the secretion of antibiotic substances from a Gram-positive, spore forming bacillus. An aliphatic $\beta$-ketoaldehyde isolated from the rhizomes inhibits the germination of seeds of higher plants (Fl. Assam, IV, 31 ; Takenaka Yukie, *J. Jap. Bot.*, 1930, **7,** 54 ; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37,** 740 ; Yashiroda, *Gdnrs' Chron.*, Ser. III, 1930, **88,** 362 ; 1931, **89,** 251 ; Warabi, *Honzo*, 1934, **24,** 65 ; Chien Pei, *Bot. Bull. Acad. sinica*, 1947, **1,** 111 ; Cheo, ibid., 1947, **1,** 298 ; *Chem. Abstr.*, 1950, **44,** 11030 ; 1951, **45,** 5759 ; 1952, **46,** 7716 ; *Japan Sci. Rev., Biol. Sci.*, 1953, No. 4, 143).

The crushed leaves of the plant have a fishy or fleshy odour. On steam-distillation, the plant yields a light brown essential oil with a strong, somewhat disagreeable odour ; it has the following characteristics: sp. gr.$^{15°}$, 0.8744 ; $n_D^{20°}$, 1.4685 ; $[\alpha]_D$, $-5°$ ; acid val., 16.65 ; sap. val., 28.40. The oil contains: methyl-*n*-nonyl ketone (m.p. of semicarbazone 122°), an aliphatic terpene (probably myrcene), a cyclic terpene and a solid acid (Fl. Malesiana, loc. cit. ; *J. Soc. chem. Ind., Lond.*, 1921, **40A,** 560).

## HOVENIA Thunb. (*Rhamnaceae*)

A monotypic genus of unarmed trees distributed in China, Japan and the hills of northern India.

**H. dulcis** Thunb. Japanese Raisin Tree, The Coral Tree.

D.E.P., IV, 301 ; Fl. Br. Ind., I, 640.

Hindi—*Sicka.*

Punjab—*Chamhun ;* Assam—*Chetia-bola ;* Nepal—*Bangikath ;* Lepcha—*Sungree-kung.*

A medium or large-sized deciduous tree, up to 100 ft. high and 11 ft. in girth, found throughout the sub-Himalayan tract, from Chamba to Bhutan, up to an elevation of 6,500 ft. and in North Bengal, Assam and Khasi and Garo hills. The bark of young trees is smooth, pale ashy or whitish ; that of old trees pale brown, rough, with deep and regular vertical fissures ; leaves 4–6 in. long and 2–3 in. broad, ovate, acuminate, glabrascent above and hairy on nerves beneath ; flowers greenish white, in pedunculate, many-flowered axillary or terminal cymes ; fruits 0.3 in. diam., globose, succulent, obscurely 3-lobed, becoming embedded when ripe in the fleshy, swollen peduncle.

The tree is found usually in moist shady places, often bordering streams. In North Bengal, it grows best above 2,000 ft., in *jhoras* and valleys with good soil. In China and Japan, it is extensively cultivated for its ornamental foliage and edible fleshy peduncles. In Russia, it has been found to thrive well under humid sub-tropical conditions. In North India, the tree flowers in May–June and fruits ripen in October–January. It is easily propagated by seeds or root cuttings or cuttings of ripened wood ; seeds can be collected in January and sown in nurseries soon after collection. Seedlings are hardy and easy to handle and thrive well when transplanted before rains (Osmaston, 108 ; Cowan & Cowan, 37 ; Rozanov, *Bull. appl. Bot. Pl.-Breed.*, 1935, Ser. XI, **2,** pt 1, 33–152 ; Macalpine, *Mem. Tocklai exp. Sta.*, No. 24, 1952, 77).

The tree is much esteemed in China and Japan for its edible peduncles, which are sweet and fleshy and taste like ripe pears. The sweetness is due to the presence of glucose (11.14%), fructose (4.74%), and sucrose (12.59%). The fruit extract contains potassium nitrate and potassium malate and is strongly diuretic. In China, dried peduncles are used medicinally. Seeds are also used for relieving intoxication due to wine (Burkill, I, 1200 ; *Chem. Abstr.*, 1950, **44,** 9014 ; 1936, **30,** 8389 ; Cheo, *Bot. Bull. Acad. sinica*, 1949, **3,** 136).

The wood of the tree is dull white, light and porous. It is not used, except as fuel. In the lower hill forests of Assam and North Bengal, where it occurs in good proportion, it is considered to be a fair timber (Fl. Assam, I, 283 ; Macalpine, loc. cit.).

## HOYA R. Br. (*Asclepiadaceae*)

A large genus of ornamental herbs and shrubs, sometimes epiphytic, distributed in tropical and subtropical Asia and Australia. About 32 species occur in India.

**H. multiflora** Blume

Fl. Br. Ind., IV, 52.

An erect epiphytic shrub, recorded from Naga hills in Assam. Leaves 4–9 in. × 1–2.5 in., oblong to oblanceolate, coriaceous, glabrous; flowers orange-coloured, in umbellate cymes; follicles 7–8 in. long, slender; seeds narrow, winged.

The juice of the plant is reported to possess diuretic properties; pounded leaves are used, in Java, as embrocation in rheumatism (Burkill, I, 1202).

**H. pendula** Wight, non Wight & Arn. = *H. iconum* Santapau

D.E.P., IV, 302; Fl. Br. Ind., IV, 61.

A slender, fleshy, twining epiphyte found throughout the greater part of the Deccan Peninsula. Leaves 1.5–3 in. long, oblong to elliptic-lanceolate, thick; flowers white, waxy, in pendulous clusters.

The plant is emetic and alexipharmic. It is also said to yield a useful fibre (Rama Rao, 264).

A number of *Hoya* species are grown in Indian gardens for their umbellate clusters of handsome waxy flowers. They love shade and good drainage and are useful for covering tree trunks, pillars, trellis, etc. Propagation is easily done by cuttings or by leaves half buried (with stalks down) in fine sand. The most commonly cultivated species is *H. carnosa* R. Br. (Common Wax Plant), a vigorously growing climber with thick, oval, rich deep green leaves and delicate, flesh-coloured flowers in compact clusters. The stems and leaves of this species contain a sterol glucoside, hoyin (0.76% in leaves; 0.832% in a mixture of 2/3 leaves and 1/3 stems) (Firminger, 449;

FIG. 82. HOYA PENDULA—FLOWERING BRANCH AND FRUIT

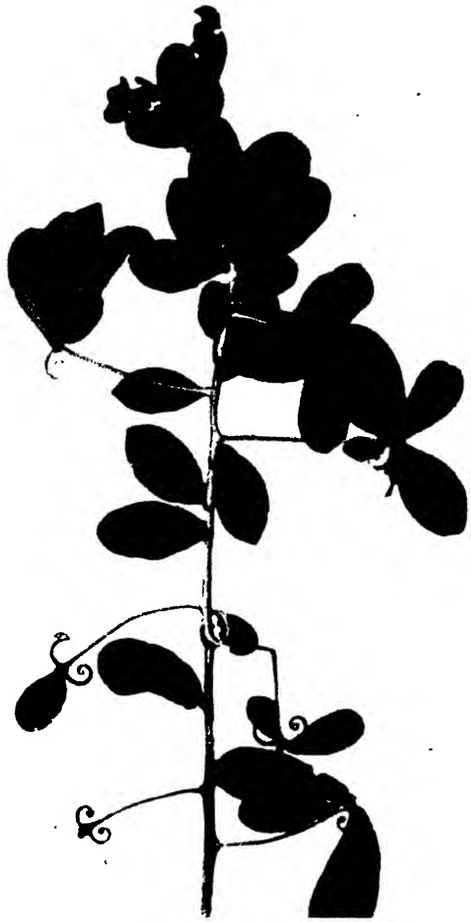


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FIG. 83. HUGONIA MYSTAX

Gopalaswamiengar, 356 : *Chem. Abstr.*, 1939, **33**, 807).

## HUGONIA Linn. (*Linaceae*)

A genus of climbing shrubs distributed in the tropics of the Old World. Two species occur in India.

### H. mystax Linn.

D.E.P., IV, 302 ; Fl. Br. Ind., I, 413 ; Kirt. & Basu, Pl. 165.

Tel.—*Kakibira, pisangi ;* Tam.—*Agori, motirakkanni ;* Kan. & Mal.—*Modirakkani ;* Oriya—*Chulijinka.*

A tomentose, rambling shrub climbing by means of opposite circinate hooks, found throughout the greater part of the Deccan Peninsula. Leaves crowded, shortly petioled, elliptic- or oblong-obovate, 1.5–3 in. long, mostly glabrous ; flowers yellow, terminal and in the upper axils ; drupes globose, *c.* 1 cm. in diam., 2 or 3 seeded.

The bruised root is applied to inflammatory swellings. The root powder is administered as an anthelmintic and febrifuge. The yellow root bark is aromatic and is employed as an antidote to poisons (Kirt. & Basu, I, 413).

## HUMBOLDTIA Vahl (*Leguminosae*)

A small genus of trees and shrubs, distributed in India, Ceylon and tropical Africa. Six species occur in India.

### H. vahliana Wight

Fl. Br. Ind., II, 274.

Tam.—*Arruvanci, nirvanchi, attuvanji ;* Mal.—*Koratthi, kara-pongu, kurappunnu.*

A moderate-sized tree found in south western ghats. Bark dark brown mottled with white ; leaves pinnate : leaflets oblong-lanceolate, acuminate ; flowers white with buff coloured calyx, in racemes ; pods almost woody, 6.0 in. × 1.5 in., pointed at both ends.

The bark is used in biliousness, leprosy, ulcers and epilepsy (Kirt. & Basu, II, 891).

The wood is light brown, moderately hard and heavy (wt., 33–40 lb./cu. ft.). It is used as fuel ; it is reported to be suitable for match boxes (Gamble, 280 ; Rama Rao, 143).

*H. laurifolia* Vahl and *H. brunonis* Wall. are small trees or shrubs found in south western ghats. The branches of *H. laurifolia* have fistular internodes inhabited by ants. The wood is greyish white, hard, close-grained and fairly durable and is suitable for posts. The wood of *H. brunonis* is useful for racquets (Lewis, 158-59 ; Trotter, 1944, 227).

*H. bourdilloni* Prain (Mal.—*Adimundan*) is a moderate-sized tree occurring in western ghats of Travancore at an altitude of *c.* 3,000 ft. The wood is greyish brown, hard, rough and heavy (wt., 48 lb./cu. ft.). The fruit is said to be eaten (Bourdillon, 131 ; Rama Rao, 144).

## HUMULUS Linn. (*Cannabinaceae*)

A genus of twining herbs distributed in the north temperate zone. *H. lupulus*, the major source of Hops used in the brewing industry, is extensively cultivated in U.S.A., South America, Europe and Australia. In India, hops have been cultivated only on an experimental scale and the entire requirements of the breweries are at present obtained by imports.

### H. lupulus Linn.

D.E.P., IV, 302 ; C.P., 759 ; Fl. Br. Ind., V, 487 ; Kirt. & Basu, Pl. 887A.

A perennial, twining, scabrid herb, 15–20 ft. in height. It is generally dioecious ; monoecious plants are occasionally found. Aerial stems (bines) oppositely branched, angular, flexible ; leaves opposite, stipulate : lower larger, 3–5 lobed, upper smaller, ovate or cordate, serrate, minutely prickly, petioles long ; male flowers small, greenish yellow, arranged in paniculate cymes ; female flowers in cone-like inflorescences ; fruit an achene.

The female inflorescences are known as hops, burrs or cones. Each cone consists of a zig-zag main axis, 1–2 in. long, covered with fine downy hair and bearing a series of opposite and alternate short lateral axes. Each lateral axis has a pair of bracts at the base and bears four female flowers, each subtended by a tubular bracteole. The outer and lower surfaces of the bracteoles and to a lesser extent, the bases of the bracts are covered with yellow pollen-like glandular trichomes, known as Hop-meal, Lupulin Glands, or Lupulin. The lupulin glands are bright golden yellow and transparent in young hops and citron yellow and opaque in the ripe ones.

Experimental cultivations of hops in the past were somewhat successful in Kashmir and Chamba, but did not succeed in Dehra Dun, Punjab and the Nilgiris. In Kashmir where hops are now grown in gardens and orchards, a considerable quantity is said to have been produced at one time for the requirements of a local brewery. Recently, at the instance of the Ministry of Food & Agriculture, experimental

cultivation of hops has been undertaken at Srinagar and Bangalore. The entire requirements of Indian breweries for hops are at present obtained from abroad. The imports which stood at 181 cwt. in 1948–49 increased to 801 cwt. during 1955–56.

Hops can be cultivated on a wide range of soils; deep, well-drained rich soils or gravelly loams are most suitable. Places with a mean summer temperature of *c.* 60°F., sheltered against strong wind and heavy rains, are considered best. Propagation is done by rhizome cuttings, 6–8 in. long and *c.* 0.5 inch in diam., having at least two pairs of buds or eyes and planted about 8 ft. apart. The vines are trained on poles or trellises, the latter being preferred. Soon after training, the lowest pair of leaves are stripped off to prevent the spread of downy mildew. All excess suckers are also removed from around the base of the plant. Only ripe or fully matured hops, which are usually bright yellowish green, sticky, crisp or papery and noticeably resilient, are picked. Unripe hops are deep green, soft and pliable, lack resiliency and the lupulin is not fully developed. Old plants yield hops of superior quality, but are usually destroyed on account of their low yield. The yield per acre in Kashmir is reported to be 4.4–5.8 cwt. as compared to 10–12 cwt. in western countries.

Among the serious diseases of hops, mention may be made of downy mildew, powdery mildew, sooty mould, root rot, crown gall, and several virus diseases. Hop plants are also attacked by a large number of insect pests. Fungicidal dusts and sprays are used as control measures [Edwardson, *Econ. Bot.*, 1952, **6**, 160: Anandaramiah, *J. Mysore hort. Soc.*, 1956, **1**(1), 36].

Freshly picked hops (moisture, 65–80%) are dried to *c.* 12% moisture; the process prevents the hops from turning brown and checks the volatilisation of the essential oil in lupulin. In U.S.A., the drying is done in natural draft or forced draft kilns at 110–115° or 145–150° depending upon the humidity of atmospheric air. Drying at high temperatures is apt to make the hops fluffy, shatter easily and impart a scorched aroma. Dried hops are cured in coolers for 10–14 days to equalise the moisture content to *c.* 12%, which renders them tough and pliable, and improves the aroma. Cured hops are stored at 32–38°F.: at higher temperatures the soft resins are partially oxidised to hard resins and the essential oil volatilises.

Commercial hops (HUMULUS) possess a strong characteristic aroma, becoming valerianaceous on ageing, and a bitter taste. Their commercial value depends on the amount and quality of lupulin glands, appearance and aroma. Hops are sometimes threshed to separate the lupulin which is sold separately. Lupulin of commerce is, however, generally obtained by sieving the sweepings of hop-room floors. It is a granular reddish brown powder with a characteristic odour and bitter aromatic taste. It darkens with age and develops valerianaceous odour. Lupulin should yield $\not>$10% acid-insoluble ash and $\not<$60% of non-volatile ether-soluble extractive (U.S.D., 1955, 1744; Youngken, 283; Trease, 212).

Hops are used in beer manufacture mainly for imparting to the beer its characteristic taste, aroma and sparkle, and also to prevent bacterial action. They also possess medicinal properties; they are aromatic and bitter with sedative, soporific, tonic, anodyne and diuretic properties. They are used with other medicines in debility, indigestion, worms and nervous conditions. Sometimes they are used in poultices (U.S.D., 1955, 1714; Hill, 258; Schery, 260; Wren, 174; Kirt. & Basu, III, 2301).

Hops contain: moisture, 6–12; resins, 11–21; volatile oil, 0.2–0.5; tannins, 2–4; nitrogenous matter as protein, 13–24; glucose and fructose, 3–4; pectins, 12–14; and ash, 7–10%; organic acids and colouring matters are also present. The tannins, which include phlobaphene, function as weak acids. The mineral constituents present include potassium, calcium and magnesium as phosphate, silicate and sulphate (Allen, VIII, 117–19; Kirk & Othmer, II, 385; Thorpe, II, 91).

The characteristic bitterness and antiseptic properties of hops are due to the presence of soft resinous bodies, $\alpha$- and $\beta$-resins; the active constituents of the resins are the bitter acidic compounds, humulone or $\alpha$-lupulinic acid ($C_{21}H_{30}O_5$: m.p., 66–66.5°) and lupulone or $\beta$-lupulinic acid ($C_{26}H_{38}O_4$; m.p., 90.5–92°). They are highly bacteriostatic against Gram-positive and acid-fast bacteria, including *Mycobacterium tuberculosis*. During the ripening of hops and drying and storage, humulone and lupulone undergo oxidation and polymerise to form respectively $\alpha$-resin and $\beta$-resin. Further transition produces the hard $\gamma$-resin with little or no commercial value. The terms $\alpha$- and $\beta$-resins or fractions customarily include both resinous bodies and acidic compounds. Fractionation of resins from fresh hops gave the following values: $\alpha$-fraction, 35 (42 or more in superior qualities); $\beta$-fraction, 46–48; and $\gamma$-resin, 12%. The antiseptic potency of the $\alpha$-fraction is much greater than that of the $\beta$-fraction. Two more compounds,

humulinone ($C_{21}H_{30}O_6$ ; m.p., 74°) and adhumulone ($C_{21}H_{30}O_5$) have recently been isolated (Thorpe, II, 92 ; Edwardson, loc. cit. ; *Chem. Abstr.*, 1950, **44,** 4194 ; 1934, **28,** 3831 ; 1949, **43,** 5444 ; 1956, **50,** 3248 ; Hort. *Abstr.*, 1950, **20,** 408 ; Heilbron & Bunbury, II, 696 ; III, 193).

Hops owe their characteristic aroma to a volatile oil present in a concentration of 0.2–0.8% (av. 0.4–0.5%) in the dried material. The oil obtained by steam-distillation of hops is a thin liquid of pale yellow colour, with a pleasant characteristic odour ; on ageing the colour changes to red brown and a cheesy odour develops. The oil has the following range of constants: sp. gr.$^{15°}_{15°}$, 0.829–0.895, occasionally up to 0.914 ; $[\alpha]_D$, −1.4° to +2.2° ; $n^{20°}$, 1.4691–1.4908, occasionally up to 1.4939 ; acid val., up to 7.0 ; ester val., 14.9–61.5 ; and solubility, usually turbid in 10 vol. of alcohol (95%). The principal constituents of the oil are myrcene (30–50%) and sesquiterpenes including humulene (15–25%) ; other constituents reported are formaldehyde, dipentene, linalool, linalyl *iso*nonylate, geraniol, myrcenol, esters of myrcenol, methyl nonyl ketone, luparol, luparenol, and free and esterified acids. Hop oil is used mainly for flavouring beer : it is also used for flavouring other cereal beverages, mineral waters, and tobacco and in some perfume compositions (Guenther, VI, 136–40).

The fibre from stems of hop plants is used for twine and for textile purposes. An extract of hops is used as a hair rinse in Russia. Spent hops from breweries are used as fodder and manure (Edwardson, loc. cit.).

## HUNNEMANNIA Sweet (*Papaveraceae*)

Bailey, 1949, 426 ; Gopalaswamiengar, 438.

A monotypic genus of shrubs native of Mexico. *H. fumariaefolia* Sweet (Mexican Tulip Poppy) is a bush 2–3 ft. high with triternately divided glaucous leaves and large, solitary, golden yellow flowers, cultivated in Indian gardens at medium and high elevations. It is propagated from seed, which should be soaked in tepid water for an hour before sowing.

The plant contains four alkaloids, viz., hunnemanine ($C_{20}H_{21}O_5N$ ; m.p., 209° ; yield, 0.18%), protopine (0.14%), allocryptopine (0.03%), and a trace of an unidentified alkaloid ($C_{22}H_{21}O_5N$ ; m.p., 174°) (Manske *et al.*, *J. Amer. chem. Soc.*, 1942, **64,** 1659).

## HUNTERIA Roxb. (*Apocynaceae*)

A small genus of trees distributed in the tropics of the Old World. One species occurs in India.

**H. zeylanica** (Retz.) Gardner ex Thw. syn. *H. corymbosa* Roxb.

D.E.P., IV, 307 ; Fl. Br. Ind., III, 637.

A small tree found in South India and Andaman Islands. Bark light brown : leaves opposite, linear-lanceolate, coriaceous, shining ; flowers white or pale yellow, in short cymes ; fruit of two globose, orange-red, 2-seeded berries.

The wood is yellowish brown, with no distinct heartwood, hard, heavy (wt., 48–58 lb./cu. ft.), and fine-textured. It is used for inlay and small articles and is suitable for carving ; it may be used as a substitute for boxwood (Burkill, I, 1203 ; Ingle & Dadswell, *Aust. J. Bot.*, 1953, **1,** 1).

The latex of the plant is used, in Malaya, for treating yaws. The leaves are applied externally for wounds and cuts in Ceylon (Burkill, I, 1203 ; Rama Rao, 252).

The bark contains 0.3% of a toxic alkaloid (Chopra, 496).

## HURA Linn. (*Euphorbiaceae*)

A small genus of trees native of tropical America. *H. crepitans* is widely cultivated in the tropics and has been introduced into India.

**H. crepitans** Linn. Sandbox Tree

D.E.P., IV, 307 ; Cooke, II, 672.

Tel.—*Simaburuga* ; Tam.—*Mullarasanam* ; Kan.—*Retidani.*

A prickly, laticiferous, monoecious tree reaching a height of over 100 ft. in its native country, cultivated in many Indian gardens. It is planted for shade on roadsides and in plantations. Leaves broadly ovate or cordate, toothed, acuminate ; flowers reddish, inconspicuous ; fruits hard, roundish, flattened, 2–3 in. diam., dehiscing with a loud explosion into a number of cocci, each containing a flattened roundish seed. Unripe fruits pierced with small holes were formerly employed as containers of sand for blotting ink. Filled with lead, they are used as paper weights (Williams & Williams, 189).

The seeds, the fresh latex, and decoction of the bark possess emeto-cathartic properties : they are violently poisonous in large doses. The toxicity is attributed to the presence of a toxalbumin, crepitin. In Java, the seeds partially roasted or pounded with honey and made into pills are used as purgative. With the embryos removed, they are said to be aperient. The kernels yield 53.8% of an oil (iod. val., 117) which is purgative. The seed cake may be used as a fertilizer. Analysis of the dry seed cake

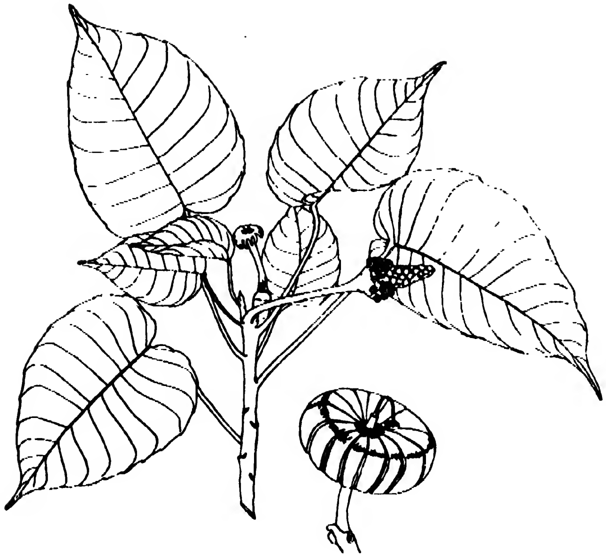


FIG. 84. HURA CREPITANS—FRUITING BRANCH

gave the following values: N, 10.12; $K_2O$, 2.13; $P_2O_5$, 1.21; and CaO, 2.34%. The ash from the seed shell is rich in potash (U.S.D., 1955, 1714; Burkill, I, 1203; *Chem. Abstr.*, 1941, **35**, 6823; Adriaens, 179).

The latex is acrid, producing erysipelatous redness and pustular eruptions on contact with the skin; it causes blindness if it gets into the eyes. It is used as a fish poison and sometimes, also as an arrow poison. In Brazil, it is employed for elephantiasis. The latex contains hurin, a compound closely related to cardol, and a proteolytic enzyme, hurain (U.S.D., 1955, 1714; Burkill, I, 1204; Jaffe, *J. biol. Chem.*, 1943, **149**, 1).

The latex, bark and seeds have been employed in the treatment of leprosy. In Java, the fruit walls are pounded and applied to sores. In Guiana, the leaves are used for chronic pains. All parts of the plant, especially fruits and seeds, show insecticidal properties (U.S.D., 1955, 1714; Burkill, I, 1204; Kirt. & Basu, III, 2288; Sievers *et al., J. econ. Ent.*, 1949, **42**, 549).

The wood is creamy white to yellowish brown, lustrous, fine-textured, soft and light (sp. gr., 0.36–0.44; wt., 23–27 lb./cu. ft.). It is firm and tenacious, easy to saw and is moderately durable. It is used for boxes, crates, interior construction, veneers and plywood (Record & Hess, 160; Hess *et al., Trop. Woods*, No. 97, 1950, 73).

**Hyacinth** — *see* **Zircon**

**Hyacinth Bean** — *see* **Dolichos**

**Hyacinth, Water** — *see* **Eichhornia**

**HYAENA** (Order, *Carnivora*; Sub-order, *Aeluroidea*)

Hyaenas belong to the Old World carnivore family *Hyaenidae* (*Feloidea*). They are similar to dogs in body build, but are distinguished from them by their large canines, carnassial teeth and broad head with large, pointed, erect ears; the forelegs are longer than the hind and a mane runs all down the neck and back. Tail short (*c.* 1½ ft.) and bushy; fore and hind limbs sturdy, four-toed with short, blunt, non-retractile claws unprotected by any sheath; body massive, *c.* 3½ ft. long: facial vibrissae or whiskers poorly developed; tongue rough; eyes dark; winter coat full and soft with under coat: summer coat short and scanty (F. Bourliere, 121).

**Striped Hyaena** (*Hyaena hyaena hyaena* Linn.)

Fn. Br. Ind., Mammalia, II, 67; Jerdon, 118; Prater, 78; Sterndale, 99.

HINDI—*Taras, hondar, jhirak, harvagh, lakar bagha, lakra*; BENG.—*Naukrabagh*; MAR.—*Taras*; TEL.—*Dumul gundu, kornagundu*; TAM.—*Kazuthaikorachi*; KAN.—*Kiraba, kut-kiraba.*

The striped hyaena is distributed from lower Kashmir to Nepal, the Terai, from Rajasthan eastwards to lower Bengal, and from Kutch southwards to the Nilgiris, probably up to Cape Comorin; it is rare in Travancore. It is found more commonly in the drier parts. Its head and body measure about 2½ ft. in length with a tail about 1½ ft. long. The canine teeth are small in comparison with the molars and are provided with protective ridges. It is cowardly by nature, but is known at times to attack sheep, goats, calves and dogs in particular. It is usually afraid of man, but recent reports from Allahabad and Bara Banki districts (U.P.) reveal that it makes bold to lift children of tender age eating up their hearts and lungs only. Its life span in captivity is 12–24 years (av. 16 years) (Ellerman & Morrison-Scott, 299).

As a solitary animal, the hyaena prefers open plains, deserts, rocky and scrub-covered hills and nullahs and open jungles. It takes shelter during day in caves, among boulders in holes dug by itself or by porcupines. Very little is known about the breeding habits of striped hyaena. Usually 3–4 young ones, covered with short, silky white hair and stripes, are born. Cubs are easily tamed. The animal produces various kinds of noises and cries, the most pronounced among them being a laughing chatter,

*Photo : M. Krishnan, Madras*

FIG. 85. STRIPED HYAENA

probably due to an impulse roused at the sight of food.

The hyaena is a natural scavenger living on carcasses of animals left over by tigers, panthers, vultures and jackals. The large teeth, especially the canines, and jaws are adapted for crushing bones.

The anal glandular pouches of striped hyaena secrete hyaenic acid ($C_{25}H_{50}O_2$? : m.p., 77–78°) as a glyceride, which may be a mixture of homologous fatty acids with an even number of carbon atoms (Thorpe, VI, 289).

In the tribal parts of India, the tongue and the fat of the animal are considered medicinal. The tongue is used for reducing tumours and swellings; it is reported to be effective for curing splints in horses (J. Huxley & Suschitzky, 11 : *J. Bombay nat. Hist. Soc.*, 1914, **23**, 145).

**Hyalite** — *see* **Opal**

**Hyalophane** — *see* **Felspar**

## HYBANTHUS Jacq. (*Violaceae*)

A genus of herbs or undershrubs distributed in the tropical and subtropical regions of the world. One species occurs in India.

**H. enneaspermus** (Linn.) F. Muell. syn. *Ionidium suffruticosum* Ging. : *I. enneaspermum* Vent.

D.E.P., IV, 475 : Fl. Br. Ind., I, 185 : Kirt. & Basu, Pl. 81.

SANS.—*Amburuha, charati* ; HINDI—*Ratanpurus* ; BENG.—*Nunbora* ; TEL.—*Nilakobari* ; TAM.—*Purusharatnam* ; MAL.—*Orelathamara, kalthamara.*

SANTAL—*Birsurajmukhi, tandisol* ; BOMBAY—*Ratanparas.*

A small diffuse perennial herb, often with woody branches, found in the warmer parts of India from Delhi to Bengal, and southwards throughout the Deccan Peninsula. Leaves subsessile, linear to oblanceolate, 1.5–2.0 in. × 0.08 – 0.3 in., entire or serrate; flowers solitary, axillary, red, spurred; fruit a small subglobose capsule containing ellipsoid, longitudinally striate, yellowish white seeds.

The plant is reported to possess tonic, diuretic and demulcent properties. The root is diuretic and administered as an infusion in gonorrhoea and urinary affections. The Santals employ the root in bowel complaints of children. The leaves and tender stalks are demulcent and used as a decoction or electuary; in conjunction with oil, they are employed in preparing a cooling liniment for the head. In Africa, the plant is added to the food of pregnant and parturient women; an infusion is also given to children (Kirt. & Basu, I, 213 ; Rama Rao, 21 ; Dalziel, 24).

FIG. 86. HYBANTHUS ENNEASPERMUS—FLOWERING & FRUITING BRANCH

**HYDNOCARPUS** Gaertn. (*Flacourtiaceae*)

A genus of trees, sometimes shrubs, distributed in south-east Asia, chiefly in the Indo-Malayan region. Four species occur in India.

The seeds of several species of *Hydnocarpus* as well as of some other genera of *Flacourtiaceae*, yield fatty oils, generally known as Chaulmoogra Oils, used extensively in the treatment of leprosy and other cutaneous diseases. Among the best known oils of the chaulmoogra group are Chaulmoogra Oil from *H. kurzii* (King) Warb., Hydnocarpus Oil from *H. laurifolia* (Dennst.) Sleumer and Lukrabo Oil or Krabao Oil from *H. anthelminthica* Pierre. *H. anthelminthica* occurs in China, Indo-China, and Siam. *H. venenata* Gaertn., a species endemic to Ceylon is also a source of chaulmoogra oil and has been erroneously considered to occur in South India. *H. kurzii* and *H. laurifolia* occur in India and their seed oils are exported to Belgium, France and Borneo. The total quantity exported from Cochin in 1955–56 was 7,057 gal., valued at Rs. 57,852 (*Annu. Rep. Cochin Chamber of Commerce*, 1955–56, 85).

The oils of the chaulmoogra group are characterised by the presence, in predominating amounts, of unsaturated cyclic fatty acids, mainly chaulmoogric and hydnocarpic; lower homologues are also reported to be present in some oils. The acids contain a cyclopentene ring at the end of the carbon chain and an asymmetric carbon and are dextrorotatory. They possess marked therapeutic value, especially in the treatment of leprosy. Both chaulmoogric and hydnocarpic acids have been synthesised. Tables 1 and 2 summarise the characteristics of the oils of chaulmoogric group and of the optically active cyclic acids (Hilditch, 1956, 220).

**H. alpina** Wight

D.E.P., IV, 308; Fl. Br. Ind., I, 196.

Mar.—*Kastel*; Tam.—*Attuchankalai*; Kan.—*Torathi, sanuasolti*; Mal.—*Malamaravetti*.

Nilgiris—*Maratatte*.

A dioecious tree attaining a height of 70–100 ft. and a girth of 2 4 ft. with a clear bole of 20–30 ft., occurring in the forests of western ghats from South Kanara to Kerala, ascending to an altitude of 6,000 ft. Leaves alternate, elliptic-oblong to lanceolate, very variable, deep green, brilliant red when young; flowers few, in axillary racemes; fruit an ovoid berry, *c.* 3 inches across; seed with a hard testa, albuminous. *H. alpina* is a good avenue tree in the hills and can be raised from seed.

The wood is light brown with darker streaks, hard, strong, heavy (sp. gr., *c.* 0.8; wt., 51 lb./cu. ft.), straight or sometimes curly-grained, even- and fine-textured. A somewhat difficult timber to season, it develops fine straight end-splits and is liable to crack on the surface in fine wavy lines. Green conversion followed by open stacking under cover is recommended. The timber is fairly durable under cover, but not so in exposed situations. It machines well and

TABLE 1—ANALYTICAL CONSTANTS OF SEED OILS FROM SOME HYDNOCARPUS SPP.

| | Oil from *H. alpina*† | Lukrabo oil from *H. anthelminthica** | Chaulmoogra oil from *H. kurzii*‡ | Hydnocarpus oil from *H. laurifolia*† | Oil from *H. venenata*† |
|---|---|---|---|---|---|
| Sp. gr. | 0.898 (at 100°) | 0.953 | 0.937–0.970 | 0.940–0.960 | 0.9475 (at 30°) |
| $n_D$ | 1.471 (at 40°) | 1.473 (at 30°) | .. | 1.472–1.476 (at 40°) | 1.477 (at 30°) |
| m.p. | 22–26° | 20–25° | .. | .. | 19–20° |
| $[\alpha]_D$ | +49.5° | +47 to +54° (at 15°) | +48° to 60° | $\not<$+53° | +52° |
| Sap. val. | 207 | 201–12 | 196–213 | 198–204 | 200.3 |
| Iod. val. | 84 | 83–91 | 96–104 | 92–103 | 99.1 |
| Acid val. | 0.35 | 8 | 20–30 | $\not>$ 5 (for injections); $\not>$10 (for ethyl ester) | 24.7 |
| Unsapon. matter (%) | .. | 1 | .. | .. | .. |
| Combined fatty acids: | | | | | |
| Titre | .. | 36–41° | .. | .. | .. |
| m.p. | .. | 42–43° | .. | .. | .. |

* Hilditch, 1941, 132. † Williams, K. A., 377. ‡ I.P., 422, 429.

**TABLE 2—CHARACTERISTICS OF OPTICALLY ACTIVE ACIDS IN OILS OF CHAULMOOGRA GROUP***

| | Mol. formula | m.p °C. | $[\alpha]_D^{25°}$ | Iod. val. |
|---|---|---|---|---|
| Chaulmoogric | $C_{18}H_{32}O_2$ | 68.5 | + 60.3 | 90.5 |
| Hydnocarpic | $C_{16}H_{28}O_2$ | 60.5 | + 69.3 | 100.7 |
| Alepric | $C_{14}H_{24}O_2$ | 48.0 | + 77.1 | 113.4 |
| Aleprylic | $C_{12}H_{20}O_2$ | 32.0 | + 90.8 | 129.7 |
| Aleprestic | $C_{10}H_{16}O_2$ | .. | +100.5** | 151.2 |
| Aleprolic | $C_6H_8O_2$ | .. | +120.5** | 226.7 |
| Gorlic | $C_{18}H_{30}O_2$ | 6.0 | + 60.7 | 182.5 |

* Cole & Cardoso, *J. Amer. chem. Soc.*, 1939, **61**, 2349. ** Calculated.

can be easily sawn in green condition. The timber is good for construction purposes and is used for beams and rafters. It has been recommended for pattern work, foot rules, picture frames, mouldings and carvings. It is also a good fuel wood (Pearson & Brown, I, 33–34 ; Gamble, 42).

The seeds contain up to 62.5% of a fatty oil which is similar to chaulmoogra oil. The pressed oil is used locally for medicinal purposes and as an illuminant. The characteristics of the oil are given in Table 1. The chief component acids are chaulmoogric and hydnocarpic (Wehmer, II, 802 ; Jamieson, 73 ; Hilditch, 1956, 221).

**H. kurzii** (King) Warb. syn. *H. heterophylla* Kurz, non Blume : *Taraktogenos kurzii* King

D.E.P., IV, 308 ; C.P., 1067 ; Fl. Assam, I, 87 ; Chopra *et al.*, Fig. 28.

Beng.—*Dalmugri, chaulmugra.*

Assam—*Lamtem, dieng-soh-lap, balibu, rowaithing.*

A tree up to 50 ft. high with tall trunk and narrow

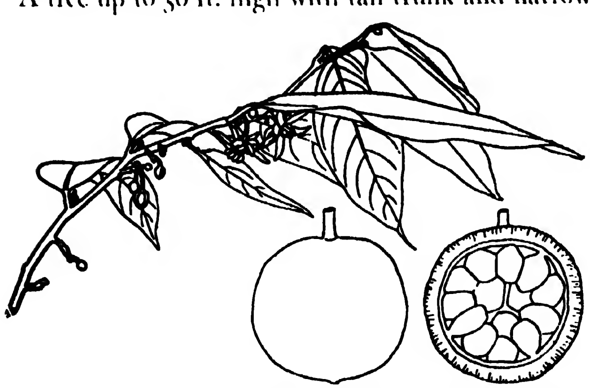
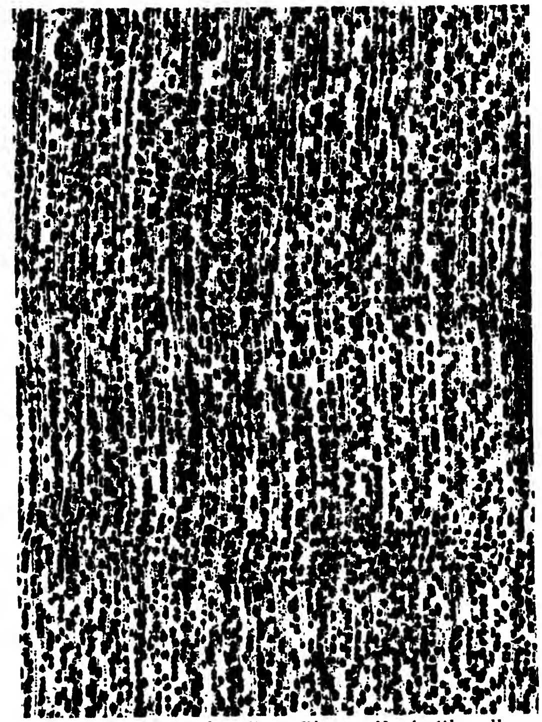


FIG. 87. HYDNOCARPUS ALPINA—FLOWERING BRANCH & FRUIT



*F.R.I., Dehra Dun. Photo : K. A. Chowdhury*

FIG. 88. HYDNOCARPUS ALPINA—TRANSVERSE SECTION OF WOOD (× 10)

crown of hanging branches, commonly found in evergreen forests throughout upper Assam and in Tripura, often forming gregarious patches. Leaves oblong or elliptic, 7–8 in. long, abruptly acuminate, coriaceous, petiole slightly geniculate at the upper end ; flowers mostly dioecious, pale yellow, in axillary cymes ; fruits chocolate-brown, globose, 2.5–3.0 in. across ; seeds numerous, c. 1 in. long, faceted, with copious albumin.

*H. kurzii* is the source of the true chaulmoogra oil. The tree bears irregularly and fruits are gathered once in 2–3 years when a full crop is expected. The yield of fruits per tree is reported to be about 300. The seeds (wt., 1–2 g. each) resemble brown pebbles in appearance and are of varying size and shape. They have poor keeping quality and seldom reach the market in fresh condition. Analysis of the seeds gave the following values: proteins, 24.2 ; oil, 30.12 ; and ash, 4.93% ; they contain a cyanogenetic glycoside (yield of hydrocyanic acid, 0.04% on kernel wt.). The seed kernel (73–85% of the weight of seed) contains 48–55% oil. Commercial oil obtained by the expression of kernels usually contains large amounts of free fatty acids and is of poor quality (Jamieson,

70 ; Hooper, *Agric. Ledger*, No. 5, 1905, 71 ; Wehmer, II, 803 ; B.P.C., 1949, 578).

Chaulmoogra oil (OLEUM CHAULMOOGRAE) is official in Indian Pharmacopoea and is employed as an external application. The ethyl esters of the oil are also used in therapy. Chaulmoogra oil was once official in B.P. but has now been replaced by hydnocarpus oil from *H. laurifolia*. Chaulmoogra oil is yellow or brownish yellow in colour with a characteristic odour resembling that of rancid butter and somewhat acrid taste. It is a soft solid fat at temperatures below 25°, sparingly soluble in 90% alcohol, but soluble in benzene, chloroform and ether. It has the following range of constants: sp. gr.$^{25°}$, 0.937–0.970 ; $[\alpha]_D$, +48° to +60° ; sap. val., 196–213 ; acid val., 20–30 ; and iod. val., 96–104. The component fatty acids of the pressed oil (iod. val., 101.5) are: chaulmoogric, 22.5 ; hydnocarpic, 34.9 ; gorlic, 22.6 ; lower homologues of hydnocarpic, 0.4 ; palmitic, 4.0 ; and oleic, 14.6% (I.P., 422 ; Thorpe, II, 523 ; Cole & Cardoso, *J. Amer. chem. Soc.*, 1939, **61**, 3442).

The seed cake is unfit for use as cattle feed because of the presence of a cyanogenetic glycoside ; it is used as manure. Analysis of the extracted meal gave the following values: nitrogen (N), 6.57 ; potash ($K_2O$), 2.21 ; and phosphoric acid ($P_2O_5$), 0.87% (Child & Nathanael, *Trop. Agriculturist*, 1943, **99**, 140 ; Jamieson, 73).

*Photo : Ramesh Bedi, Hardwar*

FIG. 89. HYDNOCARPUS KURZII—FLOWERING BRANCH

In Sikkim, the fruit pulp is sometimes eaten after boiling with water. It is used as fish poison ; however, fish killed by the use of the seed pulp should not be eaten. Wild pigs are reported to eat the fruits, and the pork of animals eating chaulmoogra fruits should not be consumed. The bark is rich in tannin and is reported to be used as febrifuge. An infusion of the bark has the odour of the essential oil of bitter almonds (Chopra *et al.*, 208 ; Burkill, I, 1209).

**H. laurifolia** (Dennst.) Sleumer syn. *H. wightiana* Blume

D.E.P., IV, 308 ; Fl. Br. Ind., I, 196 ; Kirt. & Basu, Pl. 87.

SANS.—*Garudaphala, tuvrak* ; HINDI—*Chaulmoogra* ; MAR.—*Kobased, kadu-kavata, katu-kavath, kastel, keti, kantel, kowti* ; TEL.—*Adi-badamu, niradi* ; TAM.—*Maravattai, maravetti, niradi-muttu* ; KAN.—*Toratti, surti, suranti* ; MAL. *Kodi, koti, maravetti, maroti, niralam, nirvetti, tamana, vetti.*

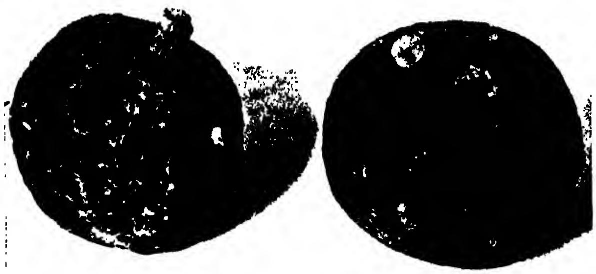
BOMBAY—*Kanti, kava.*

A dioecious evergreen tree, up to 50 ft. or more in height, often with fluted stem, commonly found in the tropical forests of western ghats from Konkan southwards. Bark brown, somewhat rough ; leaves oblong, ovate or elliptic, 4–10 in. long, more or less serrate; flowers small, greenish white, solitary or in fascicles ; fruit globose, 2–4 in. diam., tomentose, mammilate ; seeds 15–20, 0.8–1.0 in. long (wt., 1.0–1.4 g. each), subovoid, obtusely angular, striate.

*H. laurifolia* is often planted on road sides in hilly areas. It may be raised from seeds sown soon after separation from fruits. Under natural conditions, seeds germinate during the rains shortly after falling to the ground.

The seeds constitute the source of hydnocarpus oil which is by far the most important oil of the chaulmoogra group. The kernels (60–70% of the wt. of seed) contain: moisture, 8.48 ; oil, 63.25 ; nitrogenous substances, 16.75 ; and mineral matter, 3.83%. The seeds have better keeping qualities than those of *H. kurzii* and the oil pressed from them has low acid value. The oil is considered to be therapeutically superior to chaulmoogra oil (Jamieson, 75 ; Wehmer, suppl., 108 ; Child & Nathanael, *Trop. Agriculturist*, 1942, **98**, 2).

Hydnocarpus oil of B.P. or I.P. is a yellowish or brownish yellow oil or soft cream-coloured fat,



*Supt., Forest Museum, Bangalore*

FIG. 90. HYDNOCARPUS LAURIFOLIA—FRUITS

obtained by cold expression from fresh, ripe seeds of *H. laurifolia*. It has a slight characteristic odour and a somewhat acrid taste. It is soluble in most organic solvents. The constants of the oil are as follows: sp. gr.$^{25}$, 0.940–0.960; $n_D^{40}$, 1.472–1.476; $[\alpha]_D$, ∢ +53°; sap. val., 198–204; iod. val., 92–103; and acid val., ⋫5 (for injections), ⋫10 (for ethyl esters). The fatty acid composition of a specimen of the oil (iod. val., 98.4; solid acids, 84.3%; liquid acids, 15.7%) was as follows: chaulmoogric, 27.0; hydnocarpic, 48.7; gorlic, 12.2; lower homologues of chaulmoogric (alepric, aleprylic, aleprestic, aleprolic and unidentified acids), 3.4; oleic, 6.5; and palmitic, 1.8% (B.P., 264; I.P., 429; Cole & Cardoso, *J. Amer. chem. Soc.*, 1939, **61**, 2351).

Hydnocarpus oil is mainly used in the treatment of lepromatous leprosy and is effective, in early cases, in decreasing the size of nodules, anaesthetic patches and skin lesions. It is administered internally, the dosage being increased gradually to prevent gastric irritation. Intramuscular injections give better results; iodised hydnocarpus oil is said to be less painful. Sodium salts of the fatty acids have also been used (Martindale, I, 769; Chopra, 399).

Ethyl hydnocarpate (or ethyl esters of hydnocarpus oil containing mainly ethyl esters of chaulmoogric and hydnocarpic acids) possesses the therapeutic properties of the oil and is generally preferred to the latter in the treatment of leprosy: when injected, it infiltrates over a larger area and is also less irritating. Ethyl hydnocarpate is official in I.P. and B.P. and possesses the following characteristics: sp. gr.$^{20}$, 0.900–0.905; sap. val., 190–196; $n_D^{25}$, 1.458–1.462; iod. val., 88–94; acid val., ⋫1.0; and $[\alpha]_D$, ∢ +45°. A number of preparations of ethyl esters, such as Moogrol, Chaulmestrol and Antileprol, are available (Martindale, I, 769; I.P., 430; B.P.C., 1949, 591; B.P., 264; Trease, 305; Modern Drug Encyclopedia, 186).

Clinical evaluation of the curative value of hydnocarpus oil and its derivatives in leprosy has been somewhat difficult. However, it has been shown that in culture media, various hydnocarpates have a strong action in checking the growth of acid-fast *Mycobacterium leprae*. Hydnocarpus oil is also active against other acid-fast bacteria, including *Mycobacterium tuberculosis*; derivatives of the oil are more active. Sodium salts of chaulmoogric and hydnocarpic acids were reported to be bactericidal against *M. tuberculosis* in a dilution 1 : 100,000; later investigations have not yielded definite results (Kirk & Othmer, III, 651; Chopra, 395; U.S.D., 1955, 658).

Hydnocarpus oil and its derivatives turn rancid on storage and cause pain and irritation when injected. Addition of creosote (0.1–0.2%) or hydroquinone (0.02%) to hydnocarpus preparations inhibits oxidation and improves the keeping quality. Ethyl esters undergo little deterioration when stored in completely filled and well-closed containers, but rapidly develop peroxides when exposed to air (Foster *et al.*, *J. Pharm., Lond.*, 1952, **4**, 730; Basu & Mazumdar, *J. Indian chem. Soc.*, 1940, **17**, 280).

Hydnocarpus oil and its derivatives are being gradually replaced by sulphone drugs, like Promin, Diasone and Promizole, which have given promising results in the treatment of leprosy. Regression of lepromatous lesions, even of advanced nodules, has been reported by the use of sulphones (Burger, II, 839).

The press cake obtained after the expression of oil from the seeds is used as manure. Unlike the press cake from *H. kurzii* seeds, it does not contain any cyanogenetic glycoside. Analysis of extracted meal gave the following values: nitrogen (N), 6.88; potash ($K_2O$), 1.28; and phosphoric acid ($P_2O_5$), 0.93% (Child & Nathanael, *Trop. Agriculturist*, 1943, **99**, 140; Wehmer, II, 801).

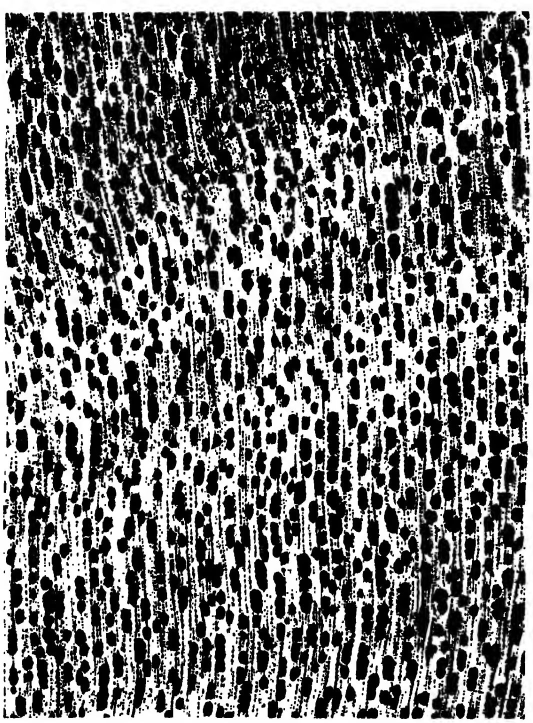
Hydnocarpus seeds have long been used in South India as a remedy for leprosy, chronic skin affections and ophthalmia, and as a dressing for wounds and ulcers. The seed oil has been recommended as a local application in rheumatism, sprains and bruises, sciatica and chest affections. Both seeds and oil act as gastro-intestinal irritants when taken internally, producing vomiting and purging. The oil is used for

burning (Kirt. & Basu, I, 225; I.P.C., 182; Chopra *et al.*, 210; Talbot, I, 80).

The fruits of the tree are used as fish poison, but fish so killed are unfit for human consumption (Rama Rao, 24).

The wood is whitish, but generally turns brownish grey due to fungal sap-stain and becomes streaked. It is somewhat lustrous when freshly exposed with a smooth feel, soft, light (sp. gr., *c.* 0.54; wt., 35 lb./cu. ft.), straight-grained, even- and fine-textured. Green conversion followed by open stacking under cover is recommended. The timber seasons without cracking, but is liable to warp and discolour; kiln-drying has also been suggested. It is not durable and is liable to insect and fungus attack. It saws easily, working to a good finish and smooth surface. The timber is used for packing cases. It is a good board wood if carefully seasoned. It is used as fuel wood: calorific value, 4,251 cal., 7,652 B.t.u. (Pearson & Brown, I, 35–36; Talbot, I, 80; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 18).

*H. castanea* Hook. f. is a tree 25–40 ft. high, with greyish bark, found in Andaman Islands. Leaves oblong to oblanceolate, 6–14 in. × 2–4 in., bluntly acuminate, base unequal, coriaceous; flowers greenish white, in fascicles; fruits ovoid, covered with yellow velvety tomentum; seeds large, angular.



*F.R.I., Dehra Dun. Photo: K. A. Chowdhury*

FIG 91. HYDNOCARPUS LAURIFOLIA—TRANSVERSE SECTION OF WOOD (× 10)

A decoction of the bark is taken internally for skin diseases and internal disorders. The wood may be used for house building (Burkill, I, 1208).

## HYDNOPHYTUM Jack (*Rubiaceae*)

Fl. Br. Ind., III, 194.

A small genus of epiphytic shrubs distributed in south-east Asia, Australia and Polynesia. One species occurs in India.

*H. andamanense* Becc. syn. *H. formicarium* Hook. f. (Fl. Br. Ind.) in part, non Jack is a small epiphytic shrub with a basal swollen tuber infested by ants, found in Andaman Islands. This species is now considered distinct from *H. formicarium* Jack distributed from Malaya eastwards to the Pacific. The two species, however, are very closely related and probably find the same uses.

The tubers of *H. formicarium* are used in the form of a decoction for liver and intestinal complaints. They are used also in poultices for headaches (Brown, 1946, III, 347; Burkill, I, 1209).

## HYDRANGEA Linn. (*Saxifragaceae*)

D.E.P., IV, 310; Fl. Br. Ind., II, 403; Bailey, 1949, 474.

A genus of shrubs and trees distributed in Asia and North and South America. Five species occur in India and a few exotics are cultivated for ornament.

Hydrangeas are grown in gardens for their handsome foliage and large showy clusters of white, pink or blue flowers. In India, they flourish in hill stations, but seldom flower in the plains; they may be grown in pots at medium elevations. They require rich light soil, free supply of water and frequent light manuring. Exposure to full morning sun gives better tresses. The plants are propagated by cuttings, divisions or suckers. As the flowers are produced only on new shoots, the branches of the previous year should be pruned back, after flowering, to 1–3 pairs of buds. Slight pruning gives many but smaller clusters, whereas heavy pruning produces more dense, but less graceful tresses. The plants are said to respond well to manuring with ammonium sulphate and to a lesser degree to blood meal and bone meal (Gopalaswamiengar, 273; Bailey, 1947, II, 1619; *Chem. Abstr.*, 1935, **29**, 5576).

The pink or blue colour of the flowers can be controlled by the quantity and composition of fertilizer mixtures and *p*H value of the soil. Acidic soils with medium nitrogen, low phosphorus and high potassium contents give blue flowers, while pink flowers are produced in alkali soils with high nitrogen, low phosphorus and high potassium contents. Sometimes the colour changes from pink to blue due to the absorption of aluminium ions from the soil; addition of aluminium salts to the soil is said to favour the production of blue flowers (*Chem. Abstr.*, 1952, **46,** 4068 : 1938, **32,** 5444 : 1935, **29,** 5576).

*H. macrophylla* (Thunb.) Ser. syn. *H. hortensis* Sm.; *H. hortensia* DC. is an ornamental shrub up to 12 ft. high, native of Japan and China and cultivated in the hill stations in India. Leaves elliptic to broadly ovate or obovate, 3-6 in. long, coarsely toothed, almost glabrous: flowers pink or blue, rarely white, in large dense clusters.

The leaves and roots of *H. macrophylla* have long been used in China as an antimalarial drug, under the name Chang Shan. The drug is reported to be more potent than quinine and its activity is attributed to the presence of an alkaloid, $C_{16}H_{19}O_3N_3 \cdot 2HCl$ : m.p., 223–25°. The leaves and roots of *Dichroa febrifuga* (q.v.) are also known as Chang Shan and similarly employed. The flowers contain hydrangenol ($C_{15}H_{12}O_4$ : m.p., 181–82°), hydrangeic acid and rutin (max. yield, 0.36%) (*Indian med. Gaz.*, 1952, **87,** 330 : *Chem. Abstr.*, 1952, **46,** 10155 : U.S.D., 1947, 1482 : *Chem. Abstr.*, 1916, **10,** 1523 : 1953, **47,** 10632).

*H. paniculata* Sieb. is a hardy shrub or a small tree up to 30 ft. high, native of Japan and China. Leaves elliptic or ovate, acuminate, serrate, pubescent; flowers white or purplish, in panicles 6-12 in. long. *H. paniculata* var. *grandiflora* Sieb. has large and showy panicles of almost sterile flowers and is the one commonly cultivated. In India, the plant thrives only in hill stations. Its blossoms contain rutin (up to 4.06% on dry basis), useful for reducing the incidence of recurrent haemorrhages associated with increased capillary fragility, particularly in hypertension (Couch & Naghski, *J. Amer. chem. Soc.*, 1945, **67,** 1419).

Extraction of the dried flowers of *H. paniculata* with benzene gave 2.5% of a phenolic compound ($C_9H_6O_3$ : m.p., 224°). A glycoside pseudohydrangin or parahydrangin, probably identical with hydrangin ($C_{31}H_{25}O_{11}$ : m.p., 228°, 235°) from the roots of *H. arborescens* Linn., is present in the roots. The inner bark contains a new glucoside, neohydrangin (m.p., 204°; $[\alpha]_D^{21}$, −130.9°) and a mucilage. On hydrolysis, neohydrangin yields umbelliferone and *d*-glucose. The essential part of the mucilage is a polyuronide containing *d*-galacturonic acid, galactose and rhamnose in the molecular ratio of 10:7:3; the polyuronide is combined with some arabinose residues (*Chem. Abstr.*, 1935, **29,** 5112 ; Merck Index, 504 ; *Chem. Abstr.*, 1925, **19,** 3481 : 1956, **50,** 4926, 7490).

*H. anomala* D. Don syn. *H. altissima* Wall. (Lepcha—*Sema-kung* ; Garhwal—*Kathmora*) is a large deciduous shrub, often epiphytic or climbing by means of adventitious roots, found in the Himalayas from the Ravi eastwards to Assam at altitudes of 4,000–10,000 ft. Leaves opposite, ovate-lanceolate, cordate, serrate; flowers whitish, greenish or bluish, in terminal clusters. The pale brown, shiny bark peels off in long papery strips; they are reported to be used as a substitute for paper. *H. aspera* Buch.-Ham. ex D. Don, a tree found in the eastern Himalayas, is reported to contain hydrocyanic acid. *H. heteromalla* D. Don syn. *H. vestita* Wall. and *H. robusta* Hook. f. & Thoms.—*H. aspera* D. Don sub sp. *robusta* (Hook. f. & Thoms.) McClintock are trees also occurring in the eastern Himalayas. The timber from these trees is whitish, moderately hard and heavy (wt., 45 lb./cu. ft. and 42 lb./cu. ft. respectively).

## HYDRILLA Rich. (*Hydrocharitaceae*)

D.E.P., IV, 310 : VI, pt 2, 31, 296, 308 : Fl. Br. Ind., V, 659.

A monotypic genus of submerged leafy water plants, occurring in tropical Asia, Australia and Central Europe. *H. verticillata* (Linn. f.) Royle (Hindi—*Jhangi, kureli* ; Beng.—*Jhangi, kureli, saola* ; Tel.—*Punachu, pachi, nachu* ; Punjab—*Jala* ; Bombay—*Sakharisheval*) is a fresh or brackish water herb with slender, branched, flaccid stems often rooting at the nodes, found throughout India in still or slow running water forming dense masses. It grows both from seed and from detached portions and winter buds. It is suitable for indoor and outdoor aquaria and is considered to be a good oxygenator; it is eaten by some types of fish. The plant may be used as green manure. It contains (dry basis): potassium, 4% (KCl, 7.6%) and mannitol, 13-14% (Chittenden, II, 1025 ; Burkill, I, 1210 : *Chem. Abstr.*, 1947, **41,** 4897).

The plant is a pest in tanks, ponds and puddles and a hindrance to anti-malarial work and pisciculture. Spraying with Dicotox (ethyl ester of 2,4-D), a chemical not harmful to fresh water fish, is reported

to be effective in controlling the pest (Biswas & Calder, *Hlth Bull*, No. 24, 1955, 72; Srinivasan & Chacko, *J. Bombay nat. Hist. Soc.*, 1952-53, **51,** 164).

**HYDROCERA** Blume (*Balsaminaceae*)

Fl. Br. Ind., I, 483.

A monotypic genus of aquatic herbs distributed in tropical Asia.

*H. triflora* Wight & Arn. (Beng.—*Domuti*) is an annual water weed occurring in ditches and ponds in Bengal and along the eastern coast of India. Stems floating, flexuous, often many yards long, fistular, rooting at the nodes and bearing long (1-2 ft.), erect, 5 angled branches: leaves alternate, sessile, linear-lanceolate, up to 5 in. long, serrate: flowers large, variegated red, white and yellow, 1-3 on axillary peduncles; fruit subglobose, succulent, with a bony truncate 5-celled stone: seeds one in each cell.

The plant is suitable for growing in gardens. It may be cultivated in pots half filled with garden soil and profusely watered. The seeds are sown in spring. Water is added up to 2 or 3 in. above the surface of the soil. The plant flowers continuously till the beginning of winter. If the pots are kept undisturbed, self-sown seedlings appear abundantly next year (Firminger, 597).

The flowers may be used in the same way as henna for dyeing finger nails. The fruits are apparently eaten by water birds (Burkill, I, 1210).

**HYDROCHARIS** Linn. (*Hydrocharitaceae*)

Fl. Br. Ind., V, 662; Coventry, I, Pl. 43.

A small genus of aquatic herbs, commonly known as Frogbits, distributed in the Old World and North America. One species occurs in India.

*H. dubia* (Blume) Backer syn. *H. morsus-ranae* Hook. f. (Fl. Br. Ind.) non Linn.; *H. asiatica* Miq.; *H. cellulosa* Buch.-Ham. ex Wall. is a pretty stoloniferous floating herb occurring in ponds and ditches in Kashmir and in parts of north-east India. Leaves petiolate, standing erect in tufts above the surface of water, rounded or reniform, up to 3 in. diam., fleshy, smooth, often reddish beneath; flowers large, white, unisexual, borne on long pedicels, arising from within 2-leaved, stalked spathes: male usually 2-3, female solitary in a spathe; fruit ovoid, fleshy, 6-celled; seeds many. The plant multiplies during summer by terminal buds borne on stolons; these drop off during winter and serve for perennation.

The leaves are mucilaginous and astringent. In Kashmir, the plant is reported to be used as fodder for cattle (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 66; Coventry, I, 88).

*H. morsus-ranae* Linn., a closely allied species, is grown in aquaria in Europe and America for its beautiful silky roots, tender leaves and delicate flowers (Bailey, 1947, II, 1624).

**HYDROCOTYLE** Linn. (*Umbelliferae*)

A genus of herbs widely distributed in the tropical and temperate regions of the world, chiefly in moist and shady places. Three species are found in India.

**H. javanica** Thunb.

Fl. Br. Ind., II, 667.

A prostrate herb found throughout the Himalayas and Assam hills at altitudes of 2,000-8,000 ft. and on the western ghats from Kanara southwards. Stems succulent, creeping, rooting at nodes and sending out branches 6–12 in. long: leaves rounded, reniform or cordate, 1-3 in. diam., subentire or lobed, crenulate, sparsely pubescent, shining; flowers greenish white, small, in crowded globular umbels, borne on peduncles 0.25–2.0 in. long; fruit minute, obovoid, compressed.

The plant is considered to be a useful soil binder and may be grown in coconut and rubber estates; there is, however, the risk of its becoming a troublesome weed. 2,4-D, particularly its mercury salt, is effective for eradicating the weed (*Peradeniya Manual*, Dep. Agric. Ceylon, No. 7, 1951; Datta & Bannerji, *Sci. & Cult.*, 1954–55, **20,** 191).

*H. javanica* is used as a substitute for *Centella asiatica* (q.v.) and is known by similar vernacular names. It is a cooling tonic, alterative and diuretic. It is also a local stimulant and is used especially in cutaneous diseases. The leaves are used as blood purifier and in indigestion, nervousness and dysentery. The leaf stalks have a pungent aromatic odour and are said to be useful in toothache. The plant is reported to possess insecticidal properties. It is used in China as a plaster for dog bite; leaves are used as fish poison (Lewis, 216; Chandrasena, 112; Kirt. & Basu, II, 1196; Fl. Malesiana, Ser. I, 1949, **4,** 115; Cheo, *Bot. Bull. Acad. sinica*, 1947, **1,** 298).

**H. sibthorpioides** Lam. syn. *H. rotundifolia* Roxb.

Fl. Br. Ind., II, 668.

A diffuse prostrate herb resembling *H. javanica*, found throughout India, ascending to an altitude of 7000 ft. Leaves orbicular, 0.25–1 inch in diam., cordate or peltate, 5-7 lobed, crenate, shining; flowers

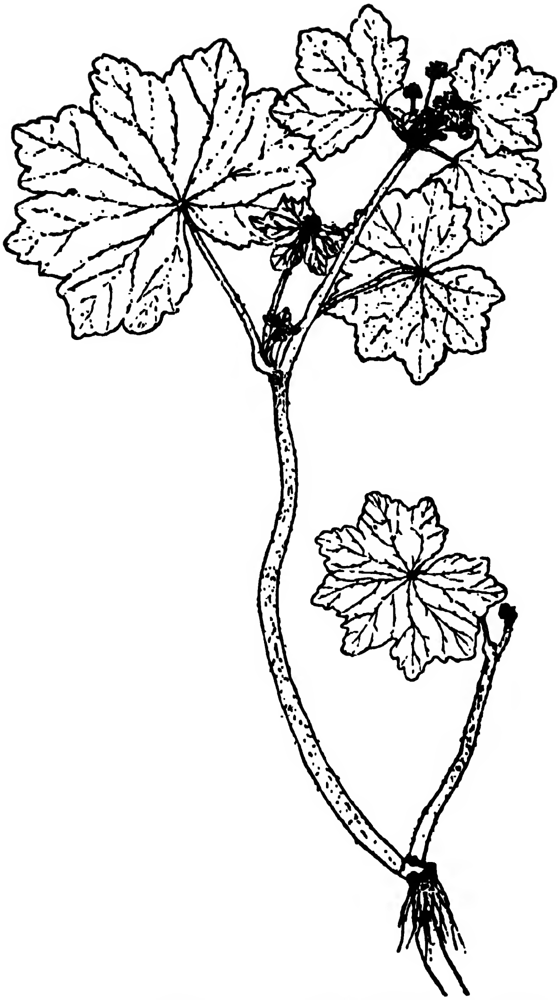


FIG. 92. HYDROCOTYLE JAVANICA—FLOWERING BRANCH

greenish white or reddish, 10–15 in an umbel; fruits compressed.

The plant is reported to be used in rheumatism, pulmonary and digestive troubles, syphilis and other skin diseases and as vermifuge and diuretic. The juice is reported to be emetic. In Indo-China, the roots are chewed in liver complaints. In Lakhimpur (Assam), the leaves are applied to boils for suppuration (*J. sci. Res. Indonesia*, 1952, **1**, suppl., 27; Chopra, 497; Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**, 402; Burkill, I, 1212).

*H. sibthorpioides* is considered suitable for cultivation as a constituent of mixed cover in tea estates; it may, however, become a troublesome weed. Application of 2,4-D in the form of its ammonium salt is effective for eradicating the weed (*Peradeniya Manual*, loc. cit.; *Chem. Abstr.*, 1945, **39**, 4186).

**Hydrocotyle asiatica** — *see* **Centella**

**HYDROLEA** Linn. (*Hydrophyllaceae*)

A genus of herbs distributed in the warm parts of the world. One species occurs in India.

**H. zeylanica** Vahl

D.E.P., IV, 315; Fl. Br. Ind., IV, 133.

SANS.—*Langali*; BENG.—*Isha-langulia, kasschra*; MAL.—*Cheruvallel*.

An erect or diffuse, often succulent herb, found in moist and swampy places throughout India, up to an altitude of 4000 ft. Stems up to 2 ft. long, rooting at the lower nodes; leaves alternate, shortly petioled, lanceolate; flowers blue, glandular hairy, on short lateral branches; capsule ovoid, enclosed in enlarged, persistent calyx; seeds numerous, minute, oblong.

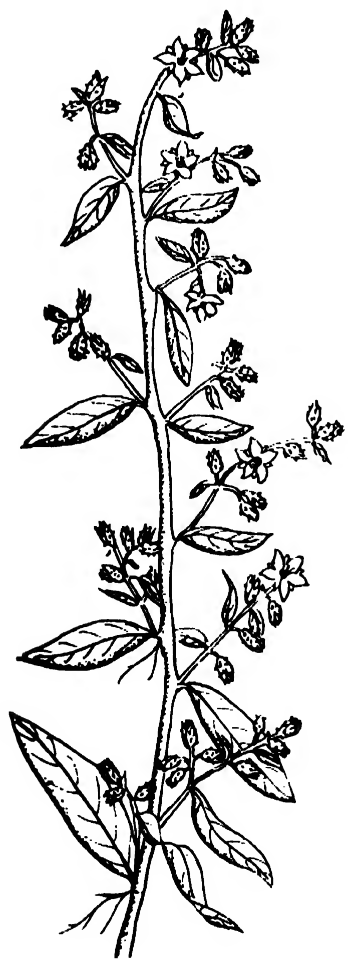


FIG. 93. HYDROLEA ZEYLANICA—FLOWERING & FRUITING BRANCH

The leaves are considered to possess cleansing and antiseptic properties; they are applied in poultices on neglected and callous ulcers (Kirt. & Basu, III, 1672).

**HYDROPHYLAX** Linn. f. (*Rubiaceae*)

Fl. Br. Ind., III, 199.

A small genus of creeping, succulent herbs distributed in the coastal regions of India, Natal and Madagascar. *H. maritima* Linn. f., a littoral herb with creeping, succulent stems, several feet long, and thick fleshy leaves is found throughout the coastal region of India and on sand hills. It is considered to be a good sand binder, though it produces very few branches and the roots at the nodes are not of great length (Fl. Madras, 653; Haines, IV, 451; Blatter, *J. Bombay nat. Hist. Soc.*, 1933, **36**, 781).

**HYGROPHILA** R. Br. (*Acanthaceae*)

A genus of herbs distributed in the tropical and sub-tropical regions of the world. About seven species occur in India.

**H. salicifolia** Nees syn. *H. angustifolia* auct., non R. Br.

D.E.P., IV, 315; Fl. Br. Ind., IV, 407.

BIHAR—*Matham arak, tonka agia, loyongtonto ara.*

An erect or ascending herb commonly met with in moist and marshy places throughout the greater part of India. Stems up to 3 ft. long, more or less quadrangular, rooting at the lower nodes; leaves subsessile, linear-lanceolate, 2.5–5 in. long; flowers pale purple, in dense axillary whorls; capsule oblong, 0.5–0.6 in. long; seeds many, ovoid, compressed, mucilaginous, hairy. The plant has been confused with *H. angustifolia* R. Br. by many authors.

The leaves are eaten as a pot-herb. They contain 18% ash rich in potassium and are strongly diuretic. In Malaya, the leaves are used for poulticing swellings (*Chem. Abstr.*, 1918, **12**, 2656; Burkill, I, 1213).

The seeds swell into a gelatinous shining mass with water and used, in Java, in poultices for headaches and fevers. They yield 25% of a fatty oil and contain traces of an unidentified alkaloid, a bitter substance, and 4% ash consisting chiefly of calcium phosphate and potassium chloride (*Chem. Abstr.*, 1918, **12**, 2656).

*H. phlomoides* Nees is an erect, rather stout herb with lanceolate to linear-oblong leaves and deeply bilipped purple flowers, found in the south-eastern parts of India. Its leaves are used in poultices for boils and headache (Burkill, I, 1213).

*H. quadrivalvis* Nees is a herb closely allied to *H. salicifolia*; it is found in various parts of the country from Bengal to Travancore. Its leaves are edible; the leaves are used in toothache and for poulticing wounds (Shivnath Rai, 33; Burkill, I, 1213).

*H. serphyllum* T. Anders. (BOMBAY—*Ran-tewan, godadi*; SAURASHTRA—*Sarpat*) is a procumbent herb with ovate-lanceolate leaves and purplish blue flowers, found from Bihar and central India to western and southern India. Its fruits are edible; the leaves are eaten in times of famine (Shivnath Rai, 33; Gammie, *Rec. bot. Surv. India*, 1902, **2**, 186).

**Hygrophila spinosa** — *see* **Asteracantha**

**HYGRORYZA** Nees (*Gramineae*)

D.E.P., III, 423; IV, 316; Fl. Br. Ind., VII, 95; Blatter & McCann, 270, Pl. 184.

A monotypic genus of aquatic grasses found in India, Ceylon, Burma and Malaya. *H. aristata* Nees (SANS.—*Aranyadhanya, aranyajali*; HINDI—*Jangli-dal*; BENG.—*Uridhan*; MAR.—*Deobhata*; GUJ.—*Vanti*; TAM.—*Vallipullu*; KAN.—*Jyarahumedhe*; MAL.—*Nirvallipullu*; ASSAM—*Phutki, putidal*), a floating glabrous grass, with culms 1.0–1.5 ft. long and narrowly oblong grains, is found almost throughout India, forming mats on the surface of water in tanks and ponds or creeping on wet ground. It is a perennial grass common in low lying areas and is often seen covering paddy fields in Assam during the rains.

The grass is said to be relished by cattle. In Assam only the leaves are used as fodder. The grains (BENGAL WILD RICE) are gathered and eaten by the poor. They are reported to be sweet, oleaginous, digestible and cooling and useful in biliousness (Fl. Madras, 1846; Fl. Assam, V, 174; Burkill, I, 1214; Das, *Bull. Dep. Agric., Assam*, No. 10, 1939, 4; Kirt. & Basu, IV, 2654).

**HYMENACHNE** Beauv. (*Gramineae*)

A genus of perennial aquatic or semiaquatic grasses, distributed in the tropics and subtropics. Two species are reported from India.

**H. amplexicaulis** (Rudge) Nees syn. *H. myurus* Beauv.; *H. pseudo-interrupta* C. Muell.; *Panicum myurus* H.B. & K. DAL GRASS

Fl. Br. Ind., VII, 39; Blatter & McCann, 155.

HINDI—*Dhamsiria.*

BOMBAY—*Pokalia*; ASSAM—*Bhat dal, dhop dal, karanga dal, tattu*; MANIPUR—*Taboo.*

A perennial, creeping or floating aquatic grass, with erect, spongy culms, 2–6 ft. high, found commonly in *beels, holas*, marshes and wet places throughout the plains of Assam, Bengal, Bihar, Orissa, Deccan and Carnatic. The grass grows well, particularly in low lands where water accumulates during the monsoon. It can be propagated by runners or seeds; propagation by runners is preferred. Planted in May–June, the grass begins to flower in November–December. It may be cut 3–4 times in a year at intervals of 2–3½ months. The yield varies from 400 to 600 maunds of green grass per acre in 3–4 cuttings [Dev Goswami, *Indian Fmg. N.S.*, 1954–55, **4**(7), 18].

The grass is relished by cattle at the flowering stage as green fodder, hay or silage, but exclusive green feeding at an early stage leads to helminthic infection. Analyses of the grass at the flowering stage and of hay and silage made from it, gave the following average values (dry basis): *green feed*—crude protein, 9.38; ether extr., 2.30; fibre, 22.10; N-free extr., 54.02; ash, 12.20; calcium, 0.13; and phosphorus, 0.206%; *hay & silage*—crude protein, 7.5, 6.94; ether extr., 1.43, 1.85; fibre, 29.20, 27.80; N-free extr., 48.97, 45.51; ash, 12.90, 17.90; calcium, 0.141, 0.175; and phosphorus, 0.186, 0.094% respectively. The average digestibility coefficients of the organic nutrients are as follows: *green feed*—crude protein, 61.5; ether extr. 37.9; crude fibre, 60.5; and N-free extr., 67.0; *hay & silage*: crude protein, 42.4, 43.9; ether extr., 39.1, 40.9; crude fibre, 70.7, 69.3; and N-free extr., 60.6, 60.3 respectively. Metabolism experiments indicate that the protein content of the grass is high enough to meet the normal requirements of adult bullocks at rest, but the calcium content is low. The grass is comparable to many cultivated fodders in its protein content (Talapatra & Dev Goswami, *Indian J. vet. Sci.*, 1949, **19**, 19).

The pith of the grass is used in Malaya and Java as a substitute for lamp wicks and in Assam, for making garlands. Studies on the influence of aquatic vegetation on the breeding habits of anopheline mosquitoes in stagnant pools have shown that dal grass has a harmful effect on the proportion of anopheline spp. attaining the adult stage (Burkill, I, 1214; Dev Goswami, loc. cit.; Sen, *J. Malar. Inst. India*, 1941–42, **4**, 113).

## HYMENOCALLIS Salisb. (*Amaryllidaceae*)

Firminger, 335; Bailey, 1949, 256.

A genus of bulbous herbs chiefly native of America. Commonly known as Spider Lilies, various species of the genus are cultivated throughout the world for their beautiful fragrant flowers. The bulbs of some species are reported to be poisonous. Three species are grown in Indian gardens.

*H. littoralis* (Jacq.) Salisb. syn. *H. americana* Roem. is an ornamental herb with strap-shaped erect leaves (1.5–2.5 ft. × 1.0–3.0 in.) and white fragrant flowers borne on a flattened scape 1–2.5 ft. high. It is usually grown on the edges of paths and blossoms appear during the rains. Propagation is done by offsets or divisions of bulbs. *H. speciosa* Salisb. and *H. tenuiflora* Herb. are other species grown in Indian gardens.

The bulbs of *H. littoralis* are used as a vulnerary in the Philippines. They contain 0.0015% lycorine ($C_{16}H_{17}O_4N$: m.p., 280°) and 0.03% tazettine ($C_{18}H_{21}O_5N$: m.p., 210–11°) (Brown, 1941, I, 381; Wildman & Kaufman, *J. Amer. chem. Soc.*, 1954, **76**, 5815).

## HYMENODICTYON Wall. (*Rubiaceae*)

A small genus of trees or shrubs distributed in the tropical and sub-tropical parts of Asia and Africa. Three species occur in India.

### H. excelsum Wall.

D.E.P., IV, 317; Fl. Br. Ind., III, 35.

SANS.—*Bhramarchhallika, ugragandha*; HINDI—*Bhaulan, kukurkat, bhurkur*; BENG.—*Latikarum*; MAR.—*Bhoursal, dancelo*; GUJ.—*Amarchhala, dondro*; TEL.—*Dudippa, dadiyetta, burja*; TAM.—*Vellei kadambu, sagapu, peranjoli*; KAN.—*Bandarayanni, vilari*; MAL.—*Itthilei, nichan, vella katampu*; ORIYA—*Bodoka, konoo*.

PUNJAB—*Kukarhat, barthoa*; NEPAL—*Latikaram*; ASSAM—*Kodom, ding-dolong-sir, phurkundi*; M.P.—*Bohar, potur*; SAURASHTRA—*Bhamarchhal*; BOMBAY—*Kola-kadu*.

TRADE—*Kuthan*.

A medium-sized to large deciduous tree usually with a rounded crown and straight cylindrical bole up to 30 ft., found scattered in the dry mixed deciduous forests throughout the greater part of India, ascending to an altitude of 5,000 ft. Bark greyish brown; leaves opposite, ovate-elliptic to obovate-oblong, 4–10 in. × 3–5 in., abruptly acuminate, pubescent; flowers small, greenish white, fragrant, crowded on the branches of erect terminal panicles; capsule ellipsoid, c. 0.75 in. long, on stout recurved pedicels; seeds numerous, small, winged.

*H. excelsum*, which requires a deep porous soil, is particularly common on loose dry deposits of boulders

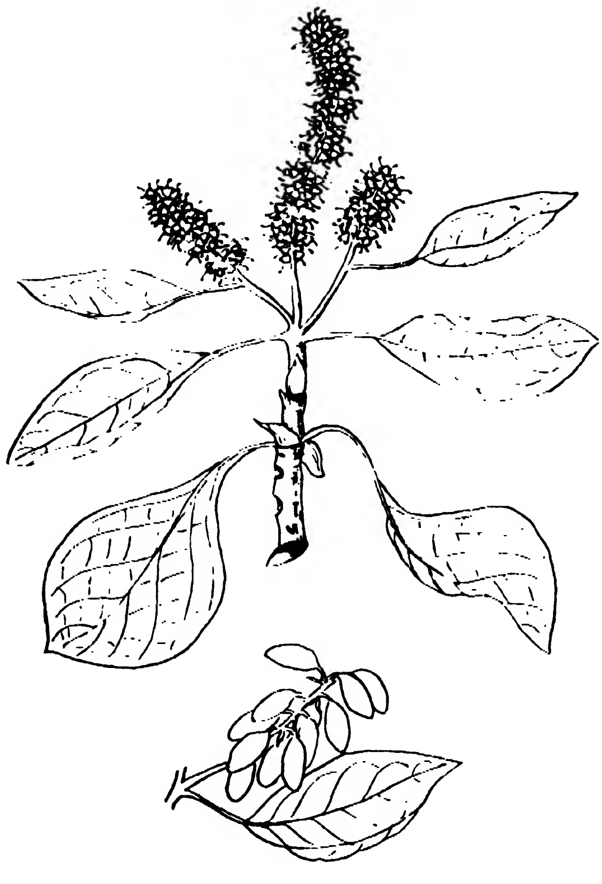


FIG. 94. HYMENODICTYON EXCELSUM—FLOWERING & FRUITING BRANCHES

and debris along the base of the outer hills in the sub-Himalayan tract; it is also frequently met with on sandy or stony soils or alluvial ground near rivers and in savannah lands. It is a strong light demander (Troup, II, 625).

The tree sheds its seeds in April–May and seeds germinate at the commencement of rains. The tree can be propagated artificially, though with some difficulty: stump planting gives better results than entire transplanting. The tree coppices freely. It grows fairly fast, the mean annual girth increment being 1.15 in. (Troup, II, 625; Kadambi & Dabral, *Indian For.*, 1955, **81**, 129).

The wood is white when first exposed, ageing to light brownish grey, with no distinct heartwood, rather lustrous, straight-grained, coarse- to even-textured and moderately soft and light (sp. gr., c. 0.50; wt., 32 lb./cu. ft.). The wood seasons well; girdling the tree and green conversion give best results. Kiln seasoning also gives satisfactory results. The wood is not durable in exposed positions or in contact with ground, but lasts fairly well under cover. It saws with ease and machines and turns well. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 70; strength as a beam, 50; stiffness as a beam, 55; suitability as a post, 50; shock-resisting ability, 55; retention of shape, 75; shear, 75; and hardness, 50 [Pearson & Brown, II, 636; Limaye, *Indian For. Rec.*, *N.S.*, *Util.*, 1944, **3**(5), 18].

The wood is used for box planking, scabbards, grain measures, rollers and bobbins for jute milling, picture and slate frames, mathematical instruments, pencils, drums and toys. It is suitable for cheap furniture, brushware, match splints, tea chest plywood, barrels and slack cooperage (Pearson & Brown, II, 636; Trotter, 1944, 121; Rehman & Askari, *Indian For.*, 1956, **82**, 314).

The bark is used for tanning. The astringent inner bark is used as a febrifuge and antiperiodic, especially for tertian ague. It contains a feebly toxic crystalline alkaloid, hymenodictyonin ($C_{23}H_{40}N_2$), and a bitter substance ($C_{20}H_{15}O_7$). The presence of aesculin (or $\beta$-methyl aesculetin) and scopoletin has also been

*F.R.I., Dehra Dun. Photo: K. A. Chowdhury*

FIG. 95. HYMENODICTYON EXCELSUM—TRANSVERSE SECTION OF WOOD (× 10)

FIG. 96. HYMENODICTYON OBOVATUM—FLOWERING & FRUITING BRANCH

reported. The powdered wood is used in herpes in Indo-China (Kirt. & Basu, II, 1259; Burkill, I, 1216; Wehmer, II, 1166; *Chem. Abstr.*, 1918, **12**, 1474, 832).

The leaves are used for dyeing and as cattle fodder. Analysis of the leaves gave: nitrogen (N), 2.36; and ash, 10.05% (Puri, *Indian For.*, 1954, **80**, 700).

**H. obovatum** Wall.

D.E.P., IV, 319; Fl. Br. Ind., II, 36.

MAR.—*Kadwa-sirid, karwai*; TAM.—*Yella mala kai, ilaimergay*; KAN.—*Bogi, hiremara, gandele*.

A medium-sized deciduous tree distributed in the monsoon forests of the western ghats. Bark thick, soft, grey, exfoliating in irregular scales; leaves obovate, 4-6 in. × 1.75–3 in., abruptly acuminate; flowers small, greenish white in dense panicled spikes; capsule ovoid, rough, on very short erect pedicel.

The inner bark is bitter and astringent; it is used as a substitute for quinine. The wood is brownish grey, soft and light to moderately heavy (wt., 28–38 lb./cu. ft.); calorific value, 4,334 cal., 7,802 B.t.u. (Bor, 291; Gamble, 407, Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 18).

**HYOSCYAMUS** Linn. (*Solanaceae*)

A genus of herbs native to the Mediterranean region and temperate Asia and introduced into many parts of the world. Two species occur in India; one exotic species has been introduced.

The dried leaves and flowering tops of a number of *Hyoscyamus* species constitute the drug HENBANE of commerce.

**H. niger** Linn. HENBANE, BLACK HENBANE

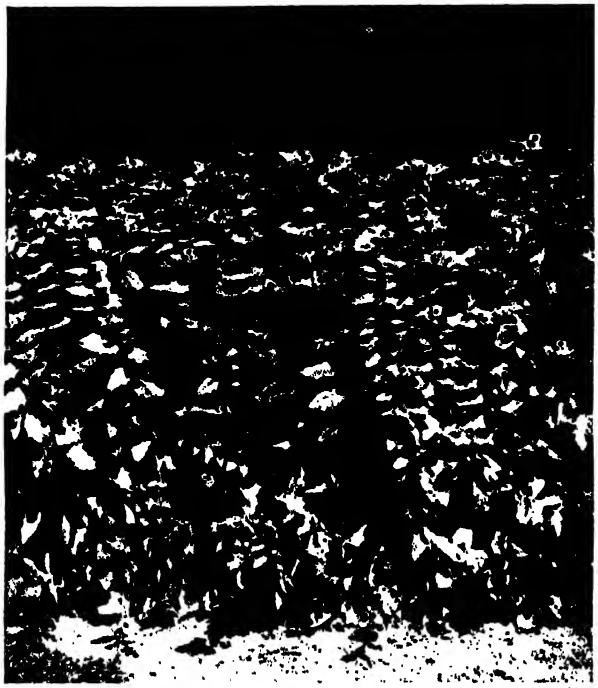
D.E.P., IV, 319; Fl. Br. Ind., IV, 244.

SANS.—*Dipya, parasikaya*; PERS.—*Bazrulbang*; HINDI—*Khurasaniajwayan*; BENG.—*Khorasaniajowan*; MAR.—*Khorasanivova*; GUJ.—*Khorasaniajmo*; TEL.—*Khurashanivamam*; TAM.—*Kurasaniyomam*; KAN.—*Khurasanivadaki*.

An erect, viscidly hairy, foetid annual or biennial, up to 5 ft. high, occurring in western Himalayas from Kashmir to Kumaon, at altitudes of 5,000–12,000 ft. Leaves radical and cauline, coarsely dentate to pinnately lobed; flowers yellowish green, sessile or sub-sessile, in terminal scorpioidal cymes; pyxidium, 0.5 in. diam.; seeds numerous, minute, oval or slightly kidney-shaped, *c.* 1.5 mm. long, brown, marked with fine but conspicuous reticulations. Attempts have been made to cultivate the plant in Kashmir, Punjab, U.P., Ajmer, Bombay and Nilgiris and plants rich in alkaloids have been successfully raised at Yarikah in Kashmir, where systematic cultivation has been undertaken.

The annual form is somewhat slender, unbranched or slightly branched; leaves less distinctly toothed than in the biennial; corolla pale with poorly developed or purplish veins. In the biennial form, the aerial stem develops only in the second year; in the first year the herb consists mainly of roots and a rosette of radical leaves. Leaves of the first year ovate-lanceolate or oblong-ovate (6–12 in. × 3–4 in.) with broad flat petioles 2 in. or more in length; those of the second year more or less sessile, ovate to triangular (2–8 in. × 1–3 in.), cordate; aerial stem coarse and hairy; flowers yellow with purple veins.

The biennial is usually cultivated for the purpose of collecting the drug. The plant requires a well-drained, fertile, sandy loam or silt loam. Forest soils and waste lands rich in organic matter and free from



*Bot. Division, I.A.R.I., New Delhi*

FIG. 97. HYOSCYAMUS NIGER—FLOWERING PLANTS

weeds are suitable. Propagation is by seed and pre-treatment with concentrated sulphuric acid for about 75 seconds followed by washing, or exposure to freezing temperatures are reported to facilitate germination. Seeds are sown broadcast or they may be sown in a nursery and seedlings transplanted in the field, the distance between plants being 4 in. When sown broadcast, the seed rate is 2–3 lb. per acre. On account of their small size, seeds are mixed with fine dry earth before sowing. Shallow sowing (0.25 in. below surface) is recommended. The seeds germinate in 2-4 weeks depending on the weather. When rosettes of radical leaves appear, the plants are thinned out and the field hoed and weeded. During transplantation, the root is likely to be injured; better results are achieved by transplanting fair-sized plants. Frequent irrigation in the early stages is necessary. Application of inorganic nitrogenous fertilizers and ample sunshine are favourable for the development of the active principles. Henbane has also been grown as a mixed crop.

The main pests of henbane are potato beetle and its larvae. Spraying of plants with rotenone and pyrethrin, and rotation of crops are effective in warding off the pest. Henbane is also affected by a few virus diseases.

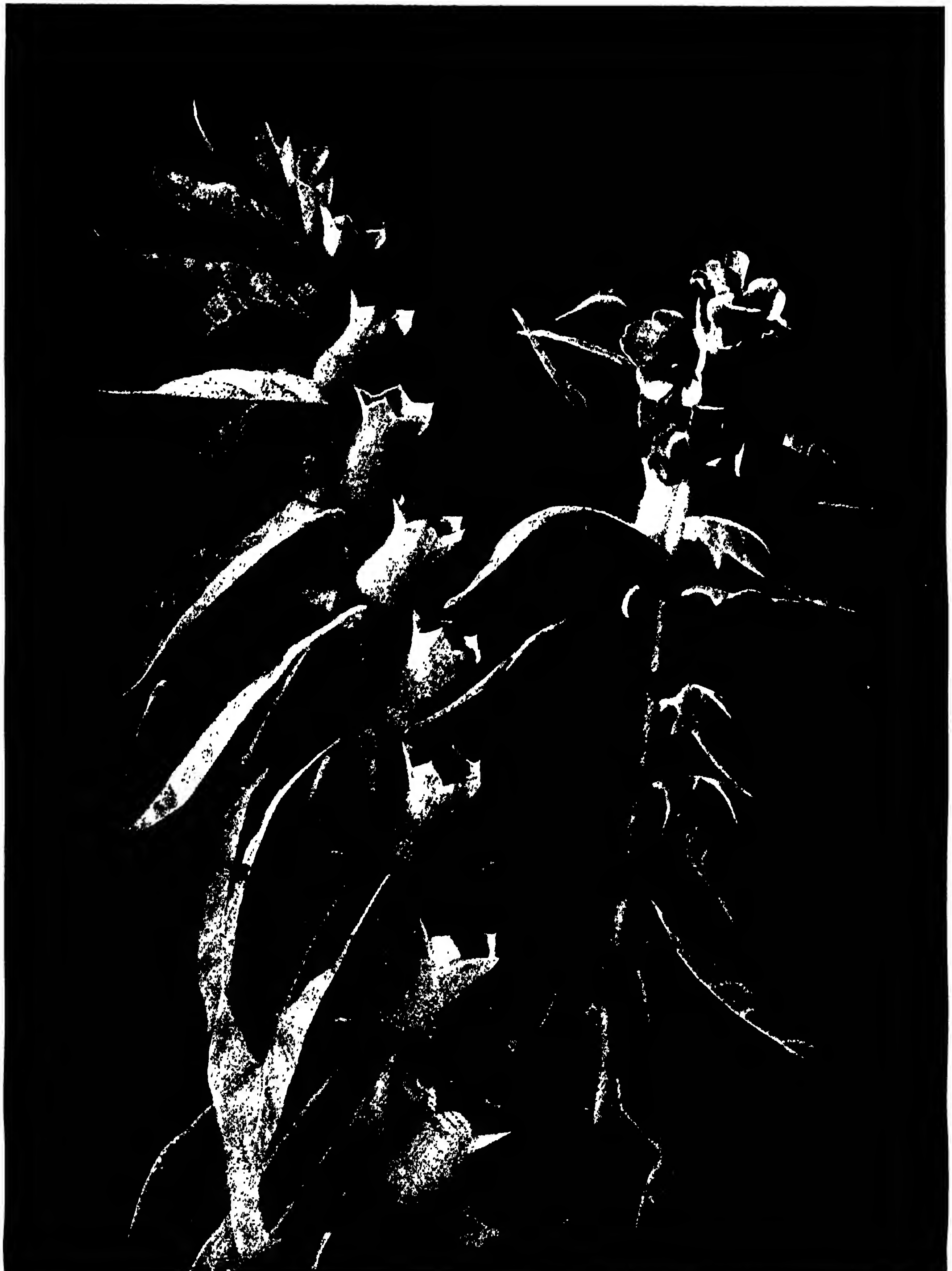
Dried leaves and flowering tops constitute the drug Henbane (HYOSCYAMUS, HYOSCYAMI HERBA). In the case of the annual, leaves and tops are picked at the time of flowering; in the case of the biennial, the first year leaf is collected late in summer and the second year leaf at the time of flowering. Leaves are dried in the sun for 3–4 days or in the shade for 7–10 days before packing. The yield of dried leaves is about 14 lb./100 lb. of green material. A yield of 2–3 md. of dry leaves per acre has been obtained at Yarikah: yields up to 6 md. are reported under favourable conditions.

For seed collection, plants are left in the field until the fruits ripen and pulled out from the roots before the fruits dehisce. They are spread in the sun for 2–3 days and raked with sticks when the fruits burst open. The seeds are then collected. A single plant yields *c.* 10,000 seeds. Seeds are stored dry and they retain their viability for several years (Kapoor *et al.*, *J. sci. industr. Res.*, 1953, **12A**, 238; *Bull. Minist. Agric., Lond.*, No. 76, 1951, 28; Trease, 501; Bentley & Trimen, III, 194; Laruelle, *J. Pharm., Lond.*, 1950, **2**, 602; Hocking, *Econ. Bot.*, 1947, **1**, 306).

Henbane is valued principally for the alkaloids present in most parts of the plant, particularly in the leaves and flowering tops. Besides the alkaloids, it contains volatile bases similar to those present in belladonna leaf, a bitter glycoside hyoscypicrin, choline, mucilage and albumin; it is rich in potassium salts. On destructive distillation, the leaves yield a poisonous empyreumatic oil (Thorpe, VI, 203; Hocking, loc. cit.; U.S.D., 1955, 674).

The total alkaloids present in the various parts of the plant are as follows: roots, 0.16; leaves, 0.045–0.08; flowering tops, 0.07-0.10; and seeds, 0.06–0.10%. Leaves collected from wild or cultivated plants in Kashmir, at altitudes above 5,000 ft. contain 0.05 to 0.092% total alkaloids. The alkaloid content of tetraploid plants, raised on an experimental scale, has been found to be considerably higher; a partial octaploid sample showed an increase of 34% in total alkaloids (Henry, 66; B.P.C., 1949, 423; Kapoor *et al.*, loc. cit.; *Chem. Abstr.*, 1946, **40**, 1631).

The alkaloid content of the leaves increases with maturity and reaches the maximum at the time of flowering, after which it decreases. The leaves of plants grown in higher altitudes (above 5,000 ft.) are richer in alkaloids than those of plants grown in the plains. The branches are richer in alkaloids than the main stem. Unripe fruits contain more alkaloids than ripe ones. The alkaloid concentration increases



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HYOSCYAMUS NIGER — FLOWERING AND FRUITING BRANCHES

in the seed with ripening and then decreases. The roots contain the highest concentration of alkaloids at the end of the vegetative period and secondary roots are richer in alkaloids than primary roots. The root bark contains more alkaloids than the wood (*Chem. Abstr.*, 1932, **26,** 3621 ; Kapoor *et al.*, loc. cit.).

The principal alkaloids present in the various parts of henbane are hyoscyamine ($C_{17}H_{23}O_3N$ ; m.p., 106-09°) and hyoscine or scopolamine ($C_{17}H_{21}O_4N$ ; m.p., 55°), the latter in a smaller quantity ; traces of tropine and scopoline are also present. Atropine occurs only in the roots of biennial plants at the end of the vegetative period. Mature leaves are richer in hyoscyamine than hyoscine ; tender leaves are relatively richer in hyoscine (Thorpe, VI, 203 ; Henry, 66 ; Hocking, loc. cit. ; U.S.D., 1955, 675 ; *Chem. Abstr.*, 1932, **26,** 3621).

Hyoscyamus is marketed in more or less compressed, flattened masses or broken pieces with a greyish green colour, clammy resinous feel, an unpleasant odour and a bitter, slightly acrid taste. The official drug contains: alkaloids (calculated as hyoscyamine), $\nless$0.05% ; ash, $\ngtr$20% ; foreign organic impurities, $\ngtr$2% ; stems with diam. more than 5 mm., $\ngtr$3%. Powdered hyoscyamus (alkaloids as hyoscyamine, $\nless$0.05%), liquid extract (alkaloids as hyoscyamine, 0.045-0.055%), dry extract (alkaloids as hyoscyamine, 0.27–0.33%) and tincture (alkaloids as hyoscyamine, 0.0045–0.0055%) are also official in B.P. (Int. P., I, 115-18 ; B.P., 270-74 ; Wallis, 291).

The therapeutic value of hyoscyamus is comparable to that of belladonna, which also contains hyoscyamine. The action of hyoscyamus, however, is modified by the presence of a comparatively larger quantity of hyoscine which produces a central narcotic effect (U.S.D., 1955, 675 ; Allport, 34).

Hyoscyamus has anodyne, narcotic and mydriatic properties. It is principally employed as a sedative in nervous affections and irritable conditions, such as asthma and whooping cough, and is substituted for opium in cases where the latter is inadmissible. It is also used to counteract the griping action of purgatives and to relieve spasms in the urinary tract. In veterinary practice, it is used as a urinary sedative. Hyoscyamus leaves have been employed externally to relieve pain, but their utility for this purpose is not well established (Kirt. & Basu, III, 1795 ; I.P.C., 121 ; B.P.C., 1949, 424).

The present output of hyoscyamus from wild plants in India is limited and falls short of the growing demand of the pharmaceutical industry. Further, collection of drug from distant and scattered places entails expenditure and the yield of alkaloids is variable. To overcome these difficulties systematic cultivation of hyoscyamus has been taken up at Yarikah in Kashmir.

The plant is used in indigenous medicine, along with other ingredients, for diabetes. Dried leaves and flowers are sometimes smoked like *ganja* (Koman, 1918, 21 ; Modi, 642).

The seeds are more or less odourless and are slightly bitter to taste. They contain an amber-coloured oil (25–30%) with the following constants: $d^{15}_{15}$, 0.923–0.939 ; $n^{40°}_{D}$, 1.4693 ; sap. val., 181-194 ; iod. val., 122-151 ; hydroxyl val., 40 ; R.M. val., 0.4-1.1 ; Polenske val., 0.4–0.6 ; Hehner val., 94.07 ; unsapon. matter, 0.3-2.6%. The component fatty acids are: myristic, 0.3 ; palmitic, 6.5 ; stearic, 1.6 ; oleic, 35.2 ; and linoleic, 56.4%. The unsaponifiable matter contains a phytosterol ($C_{28}H_{48}O.H_2O$ : m.p., 119-20°). The oil is non-toxic and edible. The meal may be utilised for the extraction of hyoscyamine and atropine. The seeds also contain gums (6.2%) and resins (Wehmer, II, 1087 ; Wallis, 294 ; Eckey, 739 ; *Chem. Abstr.*, 1934, **28,** 2557 ; 1935, **29,** 5294 ; 1937, **31,** 108).

The seeds possess anodyne and narcotic properties but they have been rarely used in medicine. They are employed mainly for the extraction of alkaloids. Mixed with wine, they are applied to gouty enlargements and swellings. Powdered seeds and smoke from burning seeds are applied to relieve toothache. A suppository prepared from seeds is used in painful affections of the uterus. The seeds are also employed in poultices for eye troubles (Burkill, I, 1217).

The plant, especially the seeds, in large doses, produces poisonous effects similar to those of datura poisoning, such as dryness of the tongue and mouth, giddiness and delirium. The plant if eaten by livestock affects the yields of milk and butter (Modi, 641 ; Chopra *et al.*, 52).

*H. muticus* Linn. (Egyptian Henbane) is a perennial herb allied to *H. niger*, distributed in the sandy parts of Egypt, extending eastwards to West Pakistan. It has been cultivated on an experimental scale in Kashmir, Saharanpur and a few other places and is known by the same vernacular names as those of *H. niger*.

The drug Egyptian Henbane (Hyoscyami Mutici Herba) from *H. muticus*, is obtained chiefly from Egypt. It differs from hyoscyamus obtained from *H. niger* by its striated cuticle and usually branched

trichomes with unicellular heads. It is generally available in matted masses of leaves intermixed with stems, flowering tops, and also a few fruits. The main macroscopic features of the drug are: stems longitudinally striated; leaves pale green to yellowish, petiolate or subsessile varying in shape from rhomboidal to broadly elliptic (up to 6 in. × 4 in.), entire or dentate; flowers yellowish brown, sometimes with deep purple patches; fruit a pyxidium; seeds minute, with reticulate testa. The drug should contain $\nless$0.5% of the alkaloids (calculated as hyoscyamine), $\ngtr$30% ash, $\ngtr$2.0% foreign organic matter and $\ngtr$1.0% of stems of more than 6 mm. diam. The drug is official in the Indian Pharmacopoea (Int. P., I, 118–20; Wallis, 295; I.P., 269).

*H. muticus* contains a higher percentage of total alkaloids than *H. niger*. The highest concentration of alkaloids is found in the floral parts. Concentration of hyoscyamin in the various parts of the Egyptian plant is as follows: leaves, up to 1.4; stems, 0.6; and seeds, 0.9–1.3%. The amount of alkaloids reported to be present in plants from Pakistan is somewhat less. The alkaloids present in the drug are hyoscyamine (c. 90% of the total alkaloids), hyoscine (0.02%), tetramethyl diaminobutane ($C_8H_{20}N_2$; b.p., 169°), and traces of atropine. The drug is used for the extraction of hyoscyamine for subsequent conversion to atropine. A product containing the total alkaloids in the form of sulphates has been found suitable for ophthalmic use (Henry, 66; Chopra *et al.*, *J. sci. industr. Res.*, 1949, **8,** 14; *Bull. imp. Inst., Lond.*, 1903, **1,** 175; *Chem. Abstr.*, 1949, **43,** 9380; B.P.C., 1949, 425; Handa & Abrol, *J. sci. industr. Res.*, 1954, **13B,** 221; Amor *et al.*, *Pharm. J.*, 1946, **157,** 88; Wehmer, II, 1088).

The leaves of *H. muticus* are smoked in Africa and India for inducing intoxication. The toxic effects are more intense than those produced by *H. niger*, leading to dryness and constriction of the throat, and severe delirium (Hill, 285; Kirt. & Basu, III, 1797).

*H. albus* Linn. is a herb with white flowers, found in the Mediterranean region. Its properties are similar to those of official henbane, for which it is often substituted. The various parts of the plant contain the following amounts of total alkaloids (hyoscyamine and hyoscine): leaves, 0.2–0.56; roots, 0.1–0.14; and seeds, 0.16%. Hyoscyamus seeds available in Indian bazaars are said to be imported from Middle East countries and probably belong to *H. albus* and *H. muticus* (Henry, 66).

*H. pusillus* Linn., a herb occurring in Ladakh, has been reported to be poisonous (Chopra & Badhwar, *Indian J. agric. Sci.*, 1940, **10,** 34).

**Hypabyssal Rocks** — *see* **Building Stones**

## HYPECOUM Linn. (*Papaveraceae*)

D.E.P., IV, 322; Fl. Br. Ind., I, 120.

A genus of herbs distributed in the Mediterranean region and temperate Asia. One species occurs in India.

*H. leptocarpum* Hook. f. & Thoms. is an annual herb found in Sikkim at altitudes of 12,000–14,000 ft. Stems many, procumbent, 6–12 in. long, much-branched; leaves bipinnatisect, uppermost linear, whorled; flowers pale purple, irregular; fruit 0.5 in. long, very slender, breaking up into one-seeded parts.

The opium alkaloid protopine ($C_{20}H_{19}O_5N$; m.p., 207°) found in a number of genera of *Papaveraceae*, has been isolated from this plant. In small doses protopine has narcotic action, slows the heart and lowers the blood pressure (Manske & Holmes, IV, 158; Henry, 299, 305).

*H. procumbens* Linn., a related species occurring in West Pakistan, also contains protopine. The juice of the plant has the same effect as opium; the leaves are diaphoretic (Henry, 173).

## HYPERICUM Linn. (*Hypericaceae*)

A genus of herbs, shrubs or small trees distributed chiefly in the temperate regions of the world. About 20 species occur in India and a few exotics are cultivated in gardens.

### H. japonicum Thunb.

Fl. Br. Ind., I, 256.

An annual, erect or procumbent herb found in the temperate and sub-tropical Himalayas, north-eastern India and the Deccan Peninsula. Stems up to 15 in. long, 4-angled; leaves amplexicaul, elliptic or ovate, pellucid-punctate; flowers yellow, in dichotomous cymes; capsules ovoid, with persistent calyx; seeds oblong, ribbed.

In China and some neighbouring countries, the plant is considered astringent, alterative and vulnerary. In Madagascar, it is used in asthma and dysentery and as styptic (Kirt. & Basu, I, 258; Burkill, I, 1217).

The plant has been suspected of causing photosensitisation, but feeding trials in New Zealand have shown that it is non-poisonous (Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 45).

FIG. 98. HYPERICUM JAPONICUM—FLOWERING PLANT

**H. patulum** Thunb.

D.E.P., IV, 323 : Fl. Br. Ind., I, 254 ; Kirt. & Basu, Pl. 101B.

NEPAL—*Urilo* ; LEPCHA—*Tumbomri* ; BIHAR—*Tumbhul* ; ASSAM—*La-syn-rit*.

A handsome, evergreen shrub up to 6 ft. high, found almost throughout the temperate Himalayas and the Khasi, Jaintia, Manipur and Naga hills of Assam at altitudes of 3,000–7,000 ft. Branches slender, reddish ; leaves opposite, sub-sessile with decurrent leaf bases, elliptic-lanceolate to ovate ; flowers bright yellow, in few-flowered terminal cymes ; capsules ovoid, *c.* 0.4 in. long ; seeds aromatic.

The seeds are employed as aromatic stimulant. In Indo-China, they are used both externally and internally for dog bites and bee stings (Kirt. & Basu, I, 255).

The wood is hard and close-grained : it can be worked to a smooth surface (Cowan & Cowan, 17).

**H. perforatum** Linn. COMMON ST. JOHN'S WORT, KLAMATH WEED.

D.E.P., IV, 323 ; Fl. Br. Ind., I, 255.

HINDI—*Bassant, balsana, dendhu*.

A rhizomatous perennial herb up to 3 ft. high, distributed in the western Himalayas at altitudes of 3,000–10,500 ft. ; stems 2-edged ; leaves opposite, sessile, oblong, ovate or linear, 0.3–1 in. long, black-dotted ; flowers yellow, *c.* 1 inch in diam., in terminal corymbose cymes ; capsule ovoid, 0.3 in. long ; seeds many, small.

The herb has a characteristic balsamic odour and a bitter, resinous, somewhat astringent taste. It is reported to possess astringent, expectorant and diuretic properties and has been used in pulmonary and urinary troubles, diarrhoea and lately in the therapy of depressional state. It has also been employed as an anthelmintic and emmenagogue. An oil known as St. John's Wort Oil (Oleum Hyperici) is prepared by infusing the fresh flowers in olive oil ; it is used externally in the treatment of wounds, sores, ulcers, swellings and sometimes against rheumatism and lumbago ; it is also valued as a sunburn oil and is recommended as a cosmetic application for tightening the skin. An ointment for use as hair restorer has been prepared from the aqueous extract of the plant (U.S.D., 1955, 1720 ; Wren, 331 ; Kirt. & Basu, I, 255 ; *Perf. essent. Oil Rec.*, 1953, **44,** 29 ; *Chem. Abstr.*, 1954, **48,** 1637).

The principal constituents of the herb are : volatile oil (yield from flowering herb, 0.06–0.11%, according to season), tannins (stems, 3.8 ; leaves, 12.4 ; and flowers, 16.2%), a resinous substance and a red fluorescent pigment, hypericin [$C_{30}H_{16}O_{8}$, (decomp. above 330°), 0.466%]. The herb also contains rutin, glucosides, alkaloids, a fixed oil, vitamin C (0.13%), provitamin A (up to 13 mg./100 g.) and the pigments pseudohypericin ($C_{30}H_{20}O_{10}$), hyperin [$C_{21}H_{20}O_{12}$ ; m.p., 237–38° (decomp.)], carotenoids, chlorophyll and a brownish red pigment. Hypericin has been identified as 4, 5, 7, 4′, 5′, 7′-hexahydroxy-2-2′-dimethyl-*meso*-naphthodianthrone ; hyperin is identical with quercetin 3-*α-d*-galactoside. The fixed oil contains glycerides of stearic, palmitic and myristic acids, ceryl alcohol, phytosterol, and two hydrocarbons ($C_{38}H_{68}$, m.p., 63° and $C_{36}H_{74}$, m.p., 68°) (U.S.D., 1955, 1720 ; *Chem. Abstr.*, 1957, **51,** 8370 ; 1955, **49,** 9231 ; Heilbron & Bunbury, II, 844 ; Brockmann & Muxfeldt, *Naturwissenschaften*, 1953, **40,** 411 ; Brockmann & Pampus, ibid., 1954, **41,** 86 ; Wehmer, II, 783 ; *Chem. Abstr.*, 1940, **34,** 5878 ; 1954, **48,** 6079 ; 1947, **41,** 7673).

The volatile oil obtained by the steam-distillation of the flowering herb shows red fluorescence, often with a greenish tinge ; it has the following constants :

sp. gr.$^{15°}$, 0.8726; $n_{D}^{15°}$, 1.489; $[\alpha]_D$, −11.72°; acid. val., 1.6; ester val., 10.6; aldehydes and ketones, 8.5%; and phenols, 3.0%. The principal constituents of the oil are terpenes and sesquiterpenes; pinene, cineol, myrcene, cadinene, gurjunene, esters of *iso*-valerianic acid (?), and hypericin are reported to be present [Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(3), suppl., 46; Wehmer, II, 783; *Chem. Abstr.*, 1934, **28**, 3179].

The plant is poisonous to livestock when eaten in excess; it leads to photosensitisation and consequent dermatitis of the unpigmented portions of the skin. It is not, however, relished by cattle. The toxicity of the plant is attributed to hypericin which occurs in all parts of the plant. Hypericin causes haemolysis of red blood cells at dilutions as low as $10^{-7}$ on exposure to light. It is similar to haematoporphyrin in its action and is reported to be effective in the treatment of endogenous or exogenous depressions. Hypericin dyes wool and silk deep violet-red while the shades produced on mordanted cotton vary from bright green yellow and brown black to weak rose; the colours have poor light- and wash-fastness (Chopra *et al.*, 216; U.S.D., 1955, 1720; Pace & Mackinney, *J. Amer. chem. Soc.*, 1941, **63**, 2570; *Chem. Abstr.*, 1947, **41**, 7121).

Aqueous extracts of the plant inhibit the growth of *Mycobacterium tuberculosis*. Acetone extracts of ripe capsules show strong *in vitro* anti-bacterial activity against *Staphylococcus aureus* (*Chem. Abstr.*, 1954, **48**, 13800; 1955, **49**, 8389).

*H. perforatum* has become a troublesome weed in some countries. Spraying with 2,4-D is reported to be effective in eradicating the weed. Biological control through insects has proved effective against a variety of this weed in Australia [Ram Gopal, *Indian Fmg, N.S.*, 1954–55, **4** (10), 23; Clark, *Aust. J. Bot.*, 1953, **1**, 95].

*H. humifusum* Linn. is a procumbent, perennial herb with elliptic to ovate leaves and few-flowered terminal cymes, occurring in Nilgiri hills. In Europe, an infusion of the flowers in olive oil or alcohol is used as a vulnerary, chiefly for old sores and eczema. *H. hookerianum* Wight & Arn. is a handsome shrub, 6–8 ft. high, with golden yellow flowers, found in Sikkim, Khasi and Jaintia hills and the Nilgiris. It is grown for hedges; its scented seeds are medicinal. *H. mysorense* Wight & Arn. is an ornamental bush, 4–6 ft. high, with fine yellow flowers, found from Konkan to Pulney hills at 3,000–5,000 ft. It is suitable for shrubberies. *H. sampsoni* Hance is a perennial herb, *c.* 1 ft. high, with oblong pellucid-punctate leaves and lax cymes, found in Khasi hills. It is reported to be used in Tonking as a vulnerary. *H. lalandii* Choisy, a tufted herb also found in Khasi hills, has a strong foetid smell [Kirt. & Basu, I, 257; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(3), suppl., 45; Firminger, 611].

Of the exotics grown in Indian gardens, *H. chinense* Linn. is a small bushy shrub with ovate-elliptic leaves and terminal cymes of bright yellow flowers. It is propagated by divisions and is said to blossom almost throughout the year. The plant is astringent and alterative and is used by the Mundas in diarrhoea and vomiting. In Indo-China, the green twigs and leaves are made into a paste and applied to dog bites and bee stings. A number of species have been introduced in the Lloyd Botanic Garden, Darjeeling (Firminger, 611; Kirt. & Basu, I, 258; Bressers, 9).

## HYPHAENE Gaertn. (*Palmae*)

A genus of palms distributed in parts of Africa, Mascarene Islands, Arabia and India. Two species are found in India.

**H. thebaica** Mart. EGYPTIAN DOUM PALM

Blatter, 161.

A dioecious, dichotomously branched tree, *c.* 40 ft. high, native of Egypt and cultivated in Indian gardens. Leaves large, fan-shaped, crowded at the ends of branches; flowers small, yellow, borne on spadices *c.* 4 ft. long, each surrounded by several cylindrical spathes; fruit obliquely ovoid or oblong, bumpy, glossy brown, punctate; seed adnate to the stone, ovate-conical, with narrow cavity surrounded by white, bony albumin.

*H. thebaica* flourishes in rich sandy loam and is propagated by seed. Its growth, flowering and fruiting are luxuriant in moist places, but in dry situations the fruits become small (Chittenden, II, 1038; Fl. Egypt, II, 275–76).

The sweet, fleshy, fibrous pericarp of the fruit, resembling ginger bread in colour and taste, is edible. In Africa, it is pounded into a meal for use in cakes and sweetmeats. A decoction of it is used as a syrup. The unripe kernel is edible and used after pounding as a substitute for millet. The trunk contains sago. The young apical bud is eaten. The part of the seedling just below the ground is also edible. Young leaves are eaten by camels (Fl. Egypt, II, 277; Dalziel, 508; Blatter, 165).

*F.R.I., Dehra Dun* *Krishna & Badhwar—Aromatic Plants*

HYPERICUM PERFORATUM — FLOWERING BRANCH

The fruit is considered astringent and anthelmintic. The bread made from it has been recommended for fluxes. The roots are used for haematuria (Fl. Egypt, II, 277–78; Caius, *J. Bombay nat. Hist. Soc.*, 1934–35, **37**, 934; Dalziel, 508).

The hard fruit stone is used for rosary beads, curtain rings, perfume and snuff boxes. The hard kernel is used as vegetable ivory for making buttons. Nuts and buttons made from them are liable to attack by scolytid beetle, *Coccotrypes dactyliperda* Fabr.; fumigation with calcium cyanide and treatment with BHC have been recommended as preventive measures. The ripe hard fruit has been used as an ingredient of preparations for dyeing leather black (Fl. Egypt, II, 277; Dalziel, 508; Tewari, *Indian For.*, 1954, **80**, 417; Rao & Janaki, *J. Bombay nat. Hist. Soc.*, 1952–53, **51**, 805).

The leaves like those of many other palms are used for thatching and for making mats, hats, baskets and bags. The fibre obtained from the leaves and roots is used for binding, rope making and fishing nets.

The wood is light brown in colour with black stripes appearing as dots in transverse section. It is strong, compact and heavy and used for posts, beams, doors, furniture, domestic utensils, waterpipes, canoes, etc. Paper of good quality is obtained from the leaf pulp, but the yield of pulp is poor. The wood yields a pulp of inferior quality (Fl. Egypt, II, 276; Chittenden, II, 1038).

*Photo: D. Chatterjee, Indian Bot. Gardens, Calcutta*

FIG. 99. HYPHAENE THEBAICA

*H. indica* Becc. (INDIAN DOUM PALM) is a closely related indigenous species, found on the west coast. It has been confused with *H. thebaica* by various authors (Burkill, *J. Bombay nat. Hist. Soc.*, 1908, **18**, 929).

## HYPOCHOERIS Linn. (*Compositae*)

Fl. Br. Ind., III, 400; Fyson, II, Pl. 301.

A genus of annual or perennial herbs, native of South America and temperate regions of the northern hemisphere. Some species have become naturalised in several parts of the world; one species occurs in India.

*H. glabra* Linn. is an annual scapigerous herb found in Nilgiri, Pulney and Travancore hills at altitudes of 4,000–8,000 ft.; it has also been recorded from Aka hills in Assam. Leaves radical, forming a rosette, oblong-lanceolate, up to 6 in. long, sinuate or pinnatifid; scapes 4–16 in. long, sometimes branched, usually several from each rosette, erect, ascending or decumbent; flowerheads small, bright yellow; achenes reddish brown, cylindrical. The fresh herb possesses vulnerary properties. Leaves are astringent. The root is tonic, aperient and diuretic (Caius, *J. Bombay nat. Hist. Soc.*, 1939-40, **41**, 846).

## HYPOLEPIS Bernh. (*Polypodiaceae*)

Beddome, Indian Ferns, 295.

A genus of ferns distributed in the tropical and temperate regions of the world. *H. punctata* (Thunb.) Mett. syn. *Phegopteris punctata* Bedd., with firm and wide-creeping rhizomes and tripinnate fronds, 1–4 ft. long, is found in the Himalayas and Assam hills at altitudes of 1,000–5,000 ft. and at higher elevations in the western ghats. The fronds are used for poulticing boils in Malaya (Burkill, I, 1218).

## HYPOXIS Linn. (*Amaryllidaceae*)

A genus of acaulescent herbs widely distributed in the warmer parts of the world. One species occurs in India.

### H. aurea Lour.

Fl. Br. Ind., VI, 277.

BIHAR—*Bhuin khajur, dinda kinda, kita bo.*

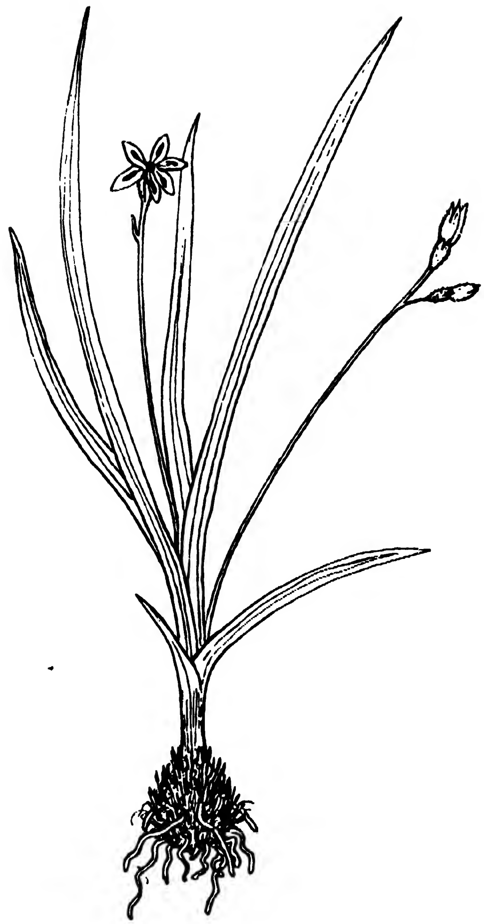

FIG. 100. HYPOXIS AUREA—FLOWERING PLANT

A hairy herb with subglobose or elongate rootstock, found in the hilly parts throughout India. Leaves radical with a sheathing base, narrowly linear, 4-14 in. × 0.1-0.6 in., subcoriaceous, keeled: flowers yellow in 1-2 flowered slender scapes; capsules oblong; seeds black, tuberculate.

The rootstock is mucilaginous and swells in water. It contains small grains of starch and bundles of raphides. In China and Malaya it is used as tonic and aphrodisiac. The crushed root is taken by Mundas in cases of emaciation and yellowing of eyes (Quisumbing, 176; Burkill, I, 1219; Bressers, 145).

**HYPSERPA** Miers (*Menispermaceae*)

Fl. Br. Ind., I, 100.

A genus of woody climbers distributed in south-east Asia. Two species occur in India.

*H. cuspidata* (Wall.) Miers syn. *Limacia cuspidata* Hook. f. & Thoms. is a somewhat stiff shrub with striate branchlets and ovate-oblong to elliptic-lanceolate, acuminate, glabrous and glossy leaves, found in parts of Assam, Sikkim, Vishakapatnam and Andaman Islands. The stems are used for making rough ropes in Indo-China. In Philippines, a fibre for bow strings is obtained from them. The leaves contain traces of an alkaloid and saponin (Burkill, I, 1220; Fox, *Philipp. J. Sci.*, 1952, **81**, 269).

**HYPTIS** Jacq. (*Labiatae*)

A large genus of herbs or shrubs, native of America. A number of species have become naturalized in warmer parts of the Old World. Four species are found in India.

**H. brevipes** Poit.

Fl. Br. Ind., IV, 630.

An erect annual herb recorded from Andaman Islands. Leaves aromatic, subsessile, lanceolate or oblanceolate, serrate, cuneate; flowers very small, in axillary or terminal globose clusters: nutlets minute, dark brown or blackish [Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 62].

The leaves are used in poultices for headache in the Philippines; they are applied on the abdomen of children against worms in Java. A decoction of the stems and leaves is taken after child birth in Malaya. The plant is reported to be beneficial for bites, stabs and other wounds. It is sometimes used as a vegetable in Malaya and as cattle fodder in Java [Fox, *Philipp. J. Sci.*, 1952, **81**, 208; Burkill, I, 1221; *J. sci. Res. Indonesia*, 1952, **1** (suppl.), 11; Dalziel, 461].

**H. capitata** Jacq.

Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 63.

An erect annual herb found in Bengal. Leaves ovate-oblong, 6–10 cm. × 3–5 cm., serrate, shortly cuneate; flowers white, in globose heads on long peduncles.

The plant is considered tonic, stimulant and excitant. In the Philippines, a decoction of the roots is used for amenorrhoea; that of leaves is used for cleansing wounds. The leaves contain a flavonol glucoside ($C_{27}H_{30}O_{15}.4H_2O$; m.p., 158–60°) which on hydrolysis gives kaempferol, glucose and rhamnose. The roots, stems and leaves are cyanogenetic (Quisumbing, 817, 1046; *Chem. Abstr.*, 1952, **46**, 6330).

**H. pectinata** Poit.

Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 64.

An erect perennial shrub found in Assam, Bengal and Madras. Leaves ovate, very variable, crenate-serrate; flowers pale purple or yellow, in cymose clusters arranged unilaterally: nutlets small, oblong, black.

In Madagascar, the plant is considered aromatic, tonic, anthelmintic, antispasmodic, emmenagogue, vermifuge and odontalgic. A decoction or infusion of the flowerheads is given in fever and for chest troubles. The leaves are used in fever and round-worms and as poultice in chest complaints. They are also employed in the treatment of horses suffering from diseases accompanied by mucous catarrh. The leaves contain an essential oil and are used for flavouring. A crystalline, bitter lactonic substance, hyptolide ($C_{18}H_{26}O_8$; m.p., 88.5°; $[\alpha]_D^{27}$, +6.75°: yield, 1%) has been isolated from the leaves (Dalziel, 460; Caius, *J. Bombay nat. Hist. Soc.*, 1940-41, **42**, 391; Githens, 92; Wehmer, II, 1075).

**H. suaveolens** Poit.

Fl. Br. Ind., IV, 630.

HINDI—*Wilayati tulsi*; BENG.—*Bilati tulsi*; ORIYA—*Ganga tulsi, purodo*.

BIHAR—*Bhunsri, dimbubuha, ara gusumpuru*.

A rigid, sweetly aromatic herb, sometimes attaining a height of 7 ft., found in Deccan Peninsula, north-east India and Andaman and Nicobar Islands. Leaves broadly ovate, very variable, 2.5–11 cm. long, sinuate-denticulate, tomentose; flowers small, blue, in unilateral axillary or terminal clusters often arranged in panicles; nutlets blackish brown, ovoid, compressed. The plant is also grown in gardens.

The plant is used as green manure in certain parts of the west coast. The shoot tops are edible. They are sometimes used for flavouring: they are also used as an adulterant for patchouli leaves. An infusion of the leaves is taken as a beverage. In Java, the plant is used as cattle fodder (Quisumbing, 818; Shivnath Rai, 34; Finnemore, 805; Dalziel, 461).

*H. suaveolens* is considered to be stimulant, carminative, sudorific and lactagogue. An infusion of the plant is used in catarrhal conditions, affections of the uterus and parasitical cutaneous diseases. The Mundas use the plant for headache and as snuff to stop bleeding of the nose. The leaf juice is taken in cases of colic and stomachaches. In the Philippines,

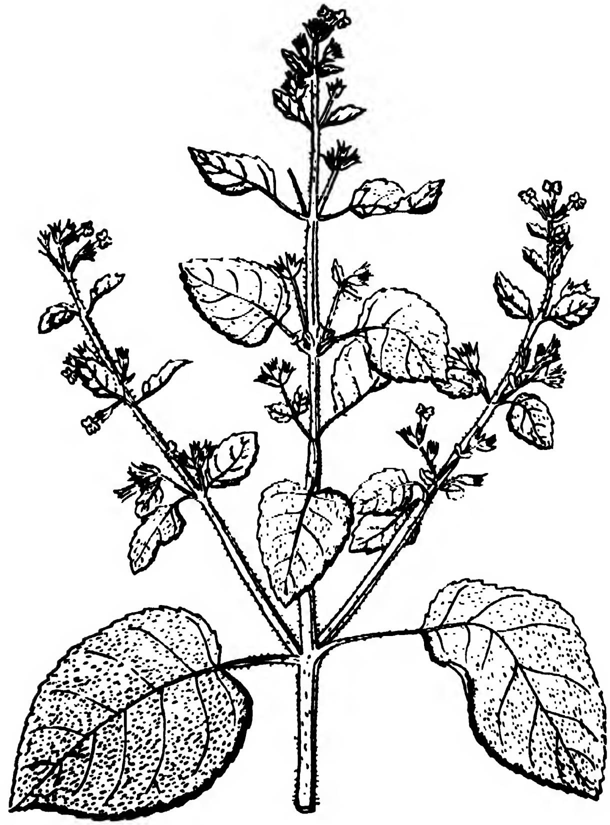

FIG. 101. HYPTIS SUAVEOLENS—FLOWERING BRANCH

the leaves and tops are considered to be antispasmodic and used in antirheumatic and antisuporific baths. A decoction of the roots is valued as an appetiser. The root is chewed with betel nuts as a stomachic (Kirt. & Basu, III, 2033; Burkill, I, 1221; Quisumbing, 818; Bressers, 118; Dalziel, 461).

The plant yields 0.06% of a greenish yellow ethereal oil with the following characteristics: sp. gr.$^{21}$, 0.8824; $n^{25}$, 1.4848; $[\alpha]_D^{25}$, −4.1°; sap. val., 6.23; sap. val. after acetylation, 49.35; and acid val., 0.2. Analysis of the oil gave: *l*-sabinene, 31; *d*-limonene, 12; azulenic sesquiterpene, 17.0; and unidentified sesquiterpenes and sesquiterpene alcohols, 40% (Nayak & Guha, *J. Indian chem. Soc.*, 1952, **29**, 183).

The seeds contain 13% of a fatty oil (iod. val., 140.2). The roots, stems and leaves contain traces of hydrocyanic acid (Jamieson, 469; Quisumbing, 1046).

**Hyssop** — *see* **Hyssopus**

**HYSSOPUS** Linn. (*Labiatae*)

A small genus of undershrubs, native of the Mediterranean region and temperate Asia and naturalised in parts of Europe and America. One species occurs in India.

**H. officinalis** Linn. HYSSOP

D.E.P., IV, 324; Fl. Br. Ind., IV, 649; Kirt. & Basu, Pl. 760 A.

An aromatic, shrubby perennial, 1-2 ft. high, found in the Himalayas from Kashmir to Kumaon at altitudes of 8,000-11,000 ft. Branches erect or diffuse; leaves sessile, linear-oblong or lanceolate, obtuse, entire; flowers bluish purple, in axillary tufts arranged unilaterally on terminal branches; nutlets dark brown, narrow, trigonous, smooth. The herb is cultivated in Europe mainly for its essential oil; it is also grown in gardens for ornament. In India, it has been successfully cultivated at Baramulla (alt., 5,500 ft.) in Kashmir. The plant thrives in light rich soil in hill stations. It may be propagated by seeds, cuttings and divisions.

The leaves and flowering tops of hyssop have an agreeable aromatic odour and a warm, pungent, bitterish taste. They are employed as flavouring for salads and soups, and also in the preparation of liqueurs and perfumes. Occasionally the green parts are used as pot-herb (U.S.D., 1947, 1486; *Econ. Bot.*, 1950, **4**, 35; Bailey, 1947, II, 1634; Chopra *et al.*, *J. sci. industr Res.* 1949, **8**, 14).

Hyssop is considered stimulant, carminative and pectoral, and used in medicine. An infusion or tea prepared from the plant is said to be effective in nervous disorders and toothache and in pulmonary, digestive, uterine and urinary troubles. The leaf juice is employed for the expulsion of round worms. The crushed herb is applied as a resolvent and vulnerary. Steeped in hot water, it is used as a fomentation for wounds, sprains and strains, muscular rheumatism and for clearing blackness due to blows. It is also used as a salve in catarrhal ophthalmia. Hyssop was at one time official in some pharmacopoeias of Europe. *Zufah yabis*, a drug sold in Indian bazaars and imported from Syria and Iran, has medicinal properties almost similar to those of hyssop. It has been referred to as *H. officinalis* by some authors, but this identity is doubtful (Kirt. & Basu, III, 1990; Caius, *J. Bombay nat. Hist. Soc.*, 1940–41, **42**, 391; Dastur, Medicinal Plants, 139).

A volatile oil (HYSSOP OIL) is obtained by the steam-distillation of the aerial parts of the plant. The yield of oil is 0.15-0.30% from fresh and 0.3-0.8% from dried materials; the maximum yield is obtained from plants harvested just after the blossoms open. Hyssop oil is used as a flavouring agent in bitters and tonics, especially in French liqueurs of the Chartreuse and Benedictine type. It is also used to some extent in perfumes with a spicy odour. In small doses (1 or 2 drops) the oil promotes expectoration in bronchial catarrh and asthma. Like the oil of sage (from *Salvia* spp.) it produces mild clonic convulsions when injected intravenously (Guenther, III, 437, 440; *Econ. Bot.*, loc cit; Caius, loc. cit; *Chem. Abstr.*, 1946, **40**, 7390).

Hyssop oil is colourless or greenish yellow with an agreeable aromatic, somewhat camphoraceous odour, and warm, slightly bitterish taste. It has the following range of constants: sp. gr.$_{15^\circ}^{15^\circ}$, 0.935-0.952; $[\alpha]_D$, $-15.75^\circ$ to $-18.3^\circ$; $n_D^{20^\circ}$, 1.4783–1.4829; sap. val., 2.8–12.1. It is soluble in 1 vol. of 80% alcohol, clear to cloudy with more; in exceptional cases incompletely soluble in 80% alcohol. Its quality is more or less uniform irrespective of the part from which the oil has been obtained, the properties varying slightly when the oil is distilled from herbs harvested during the flowering and withering periods. Steam-distilled oil from the herb collected from Baramulla (yield, 0.36 and 0.7% respectively from fresh and dried herb) had the following constants: sp. gr.$^{15^\circ}$, 0.9375 and $n_D^{20^\circ}$, 1.4778 (Guenther, III, 437; Finnemore, 736; Chopra *et al.*, loc. cit.).

About 50% of the hyssop oil consists of the ketone *l*-pinocamphone ($C_{10}H_{16}O$; b.p.$_{752}$, 212–13°; $[\alpha]_D$, $-13.7^\circ$). The presence of the following constituents has been established: $\beta$-pinene (*c.* 14%), $\alpha$-pinene, camphene, *l*-pinocampheol, an aldehyde (?), bicyclic sesquiterpenes (2-3%) and sesquiterpene alcohols (?) of the cadinene type (2%), and small amounts of primary and secondary alcohols (Guenther, III, 439-40).

Besides the volatile oil, the herb contains fat, sugar, choline, tannins, carotin (108.1 mg./100 g.) and xanthophyll (355.6 mg./ 100 g.) The tops contain ursolic acid (0.49%). A glucoside diosmin ($C_{31}H_{11}O_{21}$, $2H_2O$; m.p., 280°), which on hydrolysis yields rhamnose, glucose and the aglucone diosmetin (4′-methyl luteolin), has also been isolated. Hyssop is stated to yield a greyish green dye. The fresh herb contains iodine in a concentration of 14 $\mu$g./kg. (Wehmer, II, 1049; Heilbron & Bunbury, II, 398; McIlroy, 31; Palmer, 251; *Chem. Abstr.*, 1934, **28**, 4479; 1953, **47**, 7164; 1941, **35**, 8299; Iodine Content of Foods, 123).

# I

**IBERIS** Linn. (*Cruciferae*)

Bailey, 1949, 440.

A genus of annual and perennial herbs or undershrubs distributed chiefly in the Mediterranean region. Commonly known as CANDYTUFTS, several species of the genus are cultivated in gardens for their elegant masses of flowers.

Candytufts are popular free blooming plants useful for massing in beds or for edging plots and for cut flowers. They are well adapted for pot and pan culture and can be grown in exposed situations in light and rich garden soil, preferably calcareous. Propagation is by seeds, cuttings or divisions. Seeds may be sown at site and seedlings thinned out to 6–9 in. apart (Bailey, 1947, II, 1635; Chittenden, II, 1041; Gopalaswamiengar, 439).

*I. amara* Linn. syn. *I. coronaria* Hort. (COMMON ANNUAL CANDYTUFT, ROCKET CANDYTUFT) is an annual, about 1 ft. high, commonly cultivated in Indian gardens. It is reported to occur in Chamba at altitudes of 3,000–10,000 ft. probably as an escape. Leaves alternate, oblanceolate to spathulate, 1–4 in. long, distantly pinnatifid or toothed, sometimes entire; flowers in corymbs, later elongating into racemes, white or mauve with two outer petals larger than others; fruit a small suborbicular siliqua; seeds slightly winged.

FIG. 102. IBERIS AMARA—IN FLOWER

The plant is reported to have been employed in rheumatism and gout; it is used in the preparation of homeopathic tinctures. The seeds are used in asthma and bronchitis; they contain a mustard oil and a glycoside, glucoiberin (m.p., 134–36°) (U.S.D., 1947, 1486; Wehmer, I, 394; *Chem. Abstr.*, 1931, **25**, 2521; 1956, **50**, 11249).

Among the other species of *Iberis* cultivated in Indian gardens are: *I. sempervirens* Linn., an evergreen perennial with white or lilac flowers, and *I. umbellata* Linn. with rose-coloured or purple flowers.

**Ibex** — *see* **Wild Cattle, Sheep and Goats**

**Iceland Moss** — *see* **Cetraria, Lichens**

**Ice Plant** — *see* **Mesembryanthemum**

**ICHNANTHUS** Beauv. (*Gramineae*)

Fl. Br. Ind., VII, 60.

A small genus of annual or perennial grasses found in the tropics. *I. vicinus* Merrill syn. *I. pallens* Hook. f. (Fl. Br. Ind.), non Munro is the only species recorded in India.

*I. vicinus* is a slender, loosely branched, more or less pubescent, perennial grass, 1–2 ft. high, with broadly lanceolate, thin, flat, scabrous leaves. It occurs in the Sikkim Himalayas up to 3,500 ft. and in Assam up to 5,000 ft. It is readily eaten by cattle. Analysis of the grass gave the following values (dry matter basis): protein, 10.71; fat, 1.35; carbohydrates, 42.69; fibre, 28.23; and ash, 17.03% (Burkill, II, 1221; Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 201).

**ICHNOCARPUS** R. Br. (*Apocynaceae*)

A genus of twining shrubs distributed in south-east Asia and Australia. Three species occur in India.

FIG. 103. ICHNOCARPUS FRUTESCENS—FLOWERING BRANCH

**I. frutescens** R. Br.

D.E.P., IV, 326; Fl. Br. Ind., III, 669.

SANS.—*Syamalata, sariva, paravalli*; HINDI—*Kalidudhi, siamalata*; BENG.—*Dudhi, syamalota*; MAR.—*Krishnasarwa, kantebhouri*; TEL.—*Illukatte, nalateage*; TAM.—*Paravalli, udargodi*; MAL.—*Paalvally*; KAN.—*Karchambu, gorwiballi*; ORIYA—*Syamolota, madhobi, soyamnoi.*

DEHRA DUN—*Bel kamu*; ASSAM—*Lamkandol, paharukibandan.*

A large, evergreen, laticiferous, woody creeper with rusty red appearance, found almost throughout India, ascending up to an altitude of 4,000 ft. Leaves opposite, elliptic-oblong to broadly lanceolate, 1–4 in. ×0.5–2 in., coriaceous, pubescent when young; flowers fragrant, greenish white or purplish, in axillary or terminal panicles of cymose clusters; follicles cylindrical, slender, usually two, divaricately placed; seeds 0.5–0.7 in. long, slender, black, comose.

The roots of the plant are used in medicine as a substitute for Indian sarsaparilla (from *Hemidesmus indicus*) and are often mixed with the latter: neither their therapeutic properties nor their suitability for use as a sarsaparilla substitute have been established. They possess a sweetish astringent taste, but are devoid of the characteristic odour of Indian sarsaparilla. They are sold fresh or dried, either entire or in irregularly curved pieces of rusty or purplish brown colour. Fresh roots are somewhat turgid and when scratched or incised, exude an abundance of creamy white or light yellowish latex (moisture, 91.0; total solids, 9.0; alcohol extr., 4.66; chloroform extr., 2.93; and residue, 1.41%). The skin of fresh roots is soft and easily separable, but in dry roots it adheres firmly to the wood. Unlike the roots of Indian sarsaparilla, the roots of *I. frutescens*

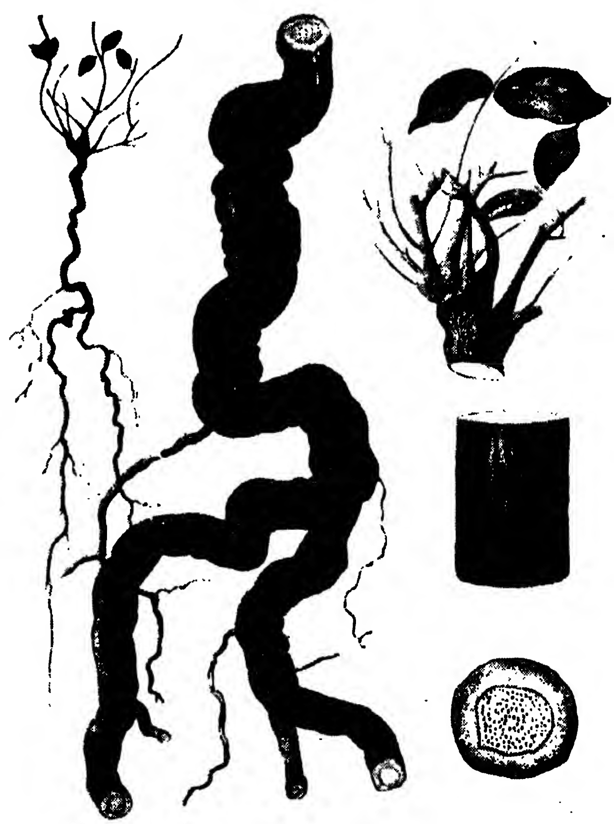

FIG. 104. ICHNOCARPUS FRUTESCENS—ROOT AND ITS TRANSVERSE SECTION

particularly the old roots, contain a central pithy core (Pharmacognosy of Ayurvedic Drugs, Series I, No. 1, 21; Viswa Nath, *J. sci. industr. Res.*, 1942–43, **1,** 335, appx. II).

The roots are reported to possess demulcent, alterative, tonic, diaphoretic and diuretic properties and are used in fevers, dyspepsia and skin troubles, usually in combination with bitters and aromatics. The root powder is administered with milk for diabetes, stone in the bladder and as blood purifier. A decoction of the shoots is used in fevers. Leaves are boiled in oil and applied in headaches and fevers; they are also applied to wounds between fingers (Kirt. & Basu, II, 1592; Nadkarni, I, 674; Rama Rao, 258; Bressers, 90).

The switchy branches are used for tying purposes, basket making and fishing nets.

*I. volubilis* Merrill syn. *I. ovatifolius* A. DC. is a woody creeper allied to *I. frutescens*, reported to occur in Chota Nagpur and parts of Assam. It is used in the Philippines for ropes, fences and fishing stakes (Burkill, II, 1221).

**Ilang-Ilang** — *see* **Cananga**

**ILEX** Linn. (*Aquifoliaceae*)

A genus of evergreen or deciduous trees and shrubs, commonly known as HOLLIES, distributed in the temperate and tropical regions of the world, chiefly in America and Asia. About 22 species occur in India; a few exotics are grown for ornament.

Some species of the genus yield valuable timber. Some contain bitter substances and are medicinal. The leaves of *I. paraguariensis* are the source of the well-known beverage, MATE or PARAGUAY TEA, extensively consumed in South America.

Hollies are grown as ornamental plants for their handsome foliage and attractive drupes. Some are valuable for hedges and roadside planting. Rich, well-drained soil suits them best, but some of them flourish in moist or even swampy places. Propagation is done by seeds which take about a year to germinate and seedlings are transplanted after the second year. The evergreen species may be propagated by ripened wood cuttings, by division, or by grafting or budding on other species (Hume, 165, 193; Bailey, 1947, II, 1637).

**I. aquifolium** Linn. ENGLISH HOLLY, COMMON HOLLY
D.E.P., IV, 327; Bailey, 1949, 629.

An evergeen shrub or tree, up to 40 ft. or more in height, with short spreading branches forming an oblong or pyramidal crown. It is a native of Europe and is occasionally cultivated in India in gardens at hill stations. Bark grey, smooth for a long time, eventually finely fissured; leaves alternate, short-petioled, elliptic or oblong, sinuate, spiny-toothed, shining, coriacious; flowers in axillary clusters, unisexual or bisexual, white or yellow, fragrant; drupes globular, about the size of peas, scarlet, shiny. A very variable species, with leaves differing greatly in size, shape and spininess; some cultivars bear blotched leaves or leaves with white or yellow margin.

The wood of common holly is white or greyish, hard, heavy (wt., 45–55 lb./cu. ft.), close-grained, fine- and uniform-textured. It finishes to a smooth surface and takes a good polish. The wood is valued according to the degree of its whiteness and should be converted soon after felling and stacked under cover in a dark dry place. It is used for inlaying, marquetry work, fancy articles and turnery; it is suitable for wood sculpture and fine cabinet work (Titmuss, 61; Howard, 250).

The fruits are reported to possess purgative, emetic and diuretic properties; they are used in dropsy and jaundice. The leaves and bark are emollient and diuretic. The leaves are bitter, somewhat acrid and at one time used in malarial fevers and gout. The flowers afford nectar for honey bees (Krumbiegel, 42; Wren, 172; U.S.D., 1947, 1487; *Indian Bee J.*, 1953, **15,** 115).

A tenacious and viscid bird-lime is prepared by cooking the inner bark of the tree for a few hours in water; the liquor is stored in a cool place till it thickens. Bird-lime was formerly used for catching small birds and rats; its use in the preparation of plasters has been suggested. Bird-lime prepared from drupes contains a sapogenic acid (possibly oleanolic) and a steroid, $\alpha$-amyrin (m.p., 181°) as $\alpha$-amyrin palmitate. The bark contains rubber (0.67%), ilicyl alcohol, ilicen ($C_{30}H_{60}$; 2% in the bark of young plants) in combination with fatty acids and pectin (U.S.D., 1947, 1364; Warth, 280; *Chem. Abstr.*, 1946, **40,** 4239; Wehmer, II, 718).

The leaves contain a crystalline yellow colouring matter, ilixanthin ($C_{31}H_{22}O_{22}$), which dyes yellow with alum and green with ferric chloride. Other constituents reported to be present in the leaves include ilexic (ilicic) acid, a bitter substance ilicin, caffeic acid, dextrose, calcium malate, an amorphous glyco-

side (?), rubber (0.5%), a resin (10.0%) and a sterol. The ash of the leaves (3.07%) contains potassium, calcium and magnesium salts (Wehmer, II, 718; *Chem. Abstr.*, 1954, **48**, 3474).

**I. malabarica** Bedd.

D.E.P., IV, 328; Fl. Br. Ind., I, 600; Talbot, I, Fig. 159.

A large tree occurring on western ghats from Konkan southwards, ascending to an altitude of 3,000 ft. Leaves alternate, elliptic or ovate-lanceolate, usually entire, acute or acuminate; flowers polygamous, in axillary fascicles or short-stalked cymes, rarely solitary, white; fruits small, red, globose.

The wood is yellowish white and hard; it is used for planks, platters and building purposes.

***I. paraguariensis** St. Hil. Mate, Yerba Mate, Paraguay Tea

D.E.P., IV, 328; Bailey, 1949, 630.

An evergreen shrub or a small tree, native of South America, and reported to be cultivated in some Indian gardens. Leaves alternate, usually 4–5 inches in length, elliptic-obovate, obtuse to obtusely acuminate, crenate-serrate, narrowed at the base; flowers axillary, fascicled or in stalked cymes; drupes rounded, up to 0.25 in. diam., reddish. The leaves constitute the source of Yerba Mate or Paraguay Tea, a beverage next only to coffee, tea and cocoa in commercial importance.

The plant may be propagated from seeds sown in the nursery; seedlings are transplanted to site after 1½-2 years. The first crop of leaves is ready for harvesting after 3-5 years. The crop yield increases continuously up to 25–30 years. Under cultivation, the plant remains small with numerous branches instead of growing into a tree with rounded crown.

The branches are cut at the time of the ripening of fruits and roasted for a brief while over fire. The leaves are then separated and dried on a platform over slow wood fire, the time taken for drying being 24–36 hr. Rapid drying in ovens is said to give an inferior product. Dried leaves are reduced to a coarse powder, placed in sacks, stacked in chambers protected from moisture and allowed to mature for about a year. A yield of 20–80 lb. of cured marketable leaf is obtained per plant according to its age (Porter, *Econ. Bot.*, 1950, **4**, 37; Trease, 364).

Like tea, mate is taken in the form of an infusion. The infusion has a pleasant aroma with a slightly bitter taste and restorative and stimulating properties. It is nutritive and mildly aperient, less astringent than tea and does not cause gastric troubles. It is beneficial in rheumatism, and in its native country, rheumatism is reported to be scarce. Mate has also been employed in U.S.A. in soft drinks and as a source of caffeine. The leaves are also used as a commercial source of chlorophyll (Hill, 479–80; Cheney, *Econ. Bot.*, 1947, **1**, 261; *World Crops*, 1953, **5**, 304).

The composition of commercial mate varies widely; the recorded ranges of values are as follows: moisture, 6.90-10.40; caffeine, 0.58–1.64; tannin, 7.8–10.98; ash, 6.09–7.38; and water extr., 35.27–49.60%. Appreciable amounts of sugar (6%), nitrogenous substances (N content, 2%), fat and wax, and small amounts of essential oil (0.08%), starch, resinous substances, vanillin, citric acid and malic acid are present. Mate is rich in vitamins and contains (av.): carotene, 1.17 mg.; thiamine, 215 μg.; riboflavin, 422 μg.; nicotinic acid, 6.9 mg.; and ascorbic acid, 11.5 mg./100 g. The mineral constituents present are (ash content of sample, 6.8%): phosphorus, 0.11; calcium, 0.68; magnesium, 0.39; potassium, 1.34; sodium, 0.0025; iron, 0.05; copper, 0.0014; manganese, 0.14; sulphur, 0.12; and chlorine, 0.113%; iodine, 160 μg./kg.; boron, silicon, aluminium and barium are present in traces. Only a part of the vitamins and minerals is extracted while infusing mate for use as beverage (Winton & Winton, IV, 90; Wehmer, II, 719; Allen, VII, 368; *Chem. Abstr.*, 1932, **26**, 6033; 1945, **39**, 3856; 1954, **48**, 6512; Iodine Content of Foods, 119).

Besides caffeine, mate contains minor amounts of theobromine and trigonelline (?). Caffeine is present also in the stem (0.52%), seed (0.17%), bark and underground parts of the plant, but not in the wood. The caffeine content of mate is less than that of tea (Wehmer, II, 719; Thorpe, VII, 539; *Chem. Abstr.*, 1930, **24**, 3534).

The aroma and flavour of mate varies with the time of collection of leaves; the maximum aroma is present when the fruits are nearly ripe. The substances to which mate owes its aroma have not been definitely identified; the flavour is retained even when mate is exposed to air and damp. The leaves contain an essential oil (Allen, VII, 367; Encylopaedia Britannica, XV, 47).

* The reported cultivation of this species in India as given in D.E.P. and followed in other publications appears to be erroneous and is probably due to a mistaken identity of the plant. A brief account of the methods of propagation and economic uses of the plant are given here as, according to some authors, the plant can be cultivated in most parts of India [Burkill, II, 1224; Krishna & Badhwar, *J. sci. industr. Res.*, 1948, **7**(10), suppl., 136].

The tannin-like constituents of mate are qualitatively similar to those present in coffee. Chromatographic examination revealed the presence of chlorogenic acid and a resinous substance, resinotanol. A phlobaphene is also present (*Chem. Abstr.*, 1953, **47**, 12529; Winton & Winton, IV, 90).

A soft white wax (yield, 2.5–3.0%) is obtained by extracting the leaves with organic solvents. The crude product is green in colour and has the following characteristics: m.p., 59–65°; sp. gr.$^{15°}$, 1.008; $n^{15°}$, 1.4698; sap. val., 110.14; acid val., 11.79; acetyl val., 68.60; fatty acids, 58.54%; and unsapon. matter, 41.78%. It may be fractionated by extraction with petroleum ether; the soft component has the following characteristics; m.p., 18–30°; sp. gr.$^{15°}$, 0.990; acetyl val., 169; and unsapon. matter, 61.08%. The unsaponifiable matter consists almost entirely of sterols including $\alpha$-amyrin (50%), cholesterol, ergosterol, matesterol ($C_{28}H_{46}O_3$; m.p., 276°), and mesoinositol. The wax may be decolourised by treatment with animal charcoal and used in cosmetics and as a softener; treatment with chlorine yields a rubber-like product (Warth, 213; *Chem. Abstr.*, 1948, **42**, 5618; 1943, **37**, 5508; 1936, **30**, 3537).

The seeds contain: moisture, 7.2; protein, 6.4; oil, 16.1; fibre, 52.0; pentosans, 17.0; and ash, 1.3%. The fatty oil has the following characteristics: sp. gr.$^{25°}$, 0.9152; $n^{25°}$, 1.4720; sap. val., 192.7; iod. val. (Hanus), 116.7; acid val., 4.4; acetyl val., 8.0; and unsapon. matter, 0.55%. The fatty acids identified are: lauric (0.87), palmitic (10.05), stearic (3.79), arachidic (0.58), oleic (34.46), palmitoleic (1.47), and linoleic (49.15%). The meal left after extracting the oil from the seeds contains: moisture, 8.6; protein, 7.6; oil, 0.2; fibre, 61.9; pentosans, 20.2; and ash, 1.5%; it is suitable for the production of furfural (*Chem. Abstr.*, 1953, **47**, 5139).

**I. umbellulata** Loes. syn. *I. sulcata* Wall. (Fl. Br. Ind.).

Fl. Br. Ind., I, 604.

ASSAM–*Bikha-kulia*.

A middle-sized tree, sometimes attaining a height of 100 ft., found in Assam. Leaves elliptic, oblong or ovate, somewhat abruptly acuminate; flowers in clusters of 12–20; drupes globose, 0.2 in. diam.

The wood of *I. umbellulata* (wt., 50 lb./cu. ft.) is white, compact and fine-grained. It is suitable for scabbards, platters and toys (Fl. Assam, I, 257).

**I. vomitoria** Ait. syn. *I. cassine* Walt., non Linn. YAUPON, CASSENA

Bailey, 1949, 630.

A much-branched evergreen shrub or a small tree, native of the coastal regions of North America and cultivated in some Indian gardens. Leaves oval or oblong, up to 2 in. long, crenate-serrate, glaucous; flowers in axillary clusters, white; fruit scarlet, 0.25 in. diam.

The leaves of this species are used, in its native habitat, as the source of a tea-like beverage, Cassena (Cassine) or Black drink. The leaves contain (air-dried sample): moisture, 13.19; water extr., 26.55; tannin, 7.39; caffeine, 0.27; and ash, 5.75%; a volatile oil, wax, resin, chlorophyll, nitrogenous substances, starch, gum and pectins are present. The volatile oil has a pleasant odour, suggestive of tea and raw tobacco (Hume, 129; Allen, VII, 369; Wehmer, II, 719).

An infusion of cassena is employed in medicine as a tonic; in large doses it acts as emetic. A syrup for use in soft drinks and an alcoholic extract for use as a flavouring agent, have been prepared from the leaves. The leaves may also be used as a source of caffeine (Hill, 482; Cheney, *J.N.Y. bot. Gdn*, 1942, **43**, 122; Allen, VII, 369).

**I. wightiana** Wall.

Fl. Br. Ind., I, 603; Fyson, II, Pl. 84.

TAM. & KAN.—*Badaga, hurulu*.

A medium-sized tree with numerous, steeply sloping branches, found on the hills of South India, particularly on Nilgiris. Leaves alternate, elliptic-oblong or ovate, subacute or acuminate; flowers in clusters, white; drupes globose, 0.25 in. diam.

The wood of *I. wightiana* (wt., 35–40 lb./cu. ft.) is pale white or creamy in colour, rather soft and close-grained. It is useful for platters, bowls, tea boxes, packing cases, cabinet work and building purposes (Gamble, 169; Lewis, 102).

Among the other Indian species of *Ilex*, the following occurring in the Himalayas and hills of Assam yield timbers, though of poor quality: *I. dipyrena* Wall., *I. excelsa* Wall. syn. *I. doniana* DC., *I. godajam* Colebr., *I. insignis* Hook. f., *I. odorata* Buch.-Ham., and *I. theaefolia* Hook. f. *I. denticulata* Wall. found on Anamalai and Nilgiri hills also yields a timber of poor quality. The leaves of *I. dipyrena* are occasionally used as fodder for sheep. The bark of *I. godajam*, which is thick, soft and horizontally wrinkled, is used

in Indo-China in the form of a decoction for diarrhoea and as diuretic (Crevost & Petelot, *Bull. econ. Indoch.*, 1935, **38**, 145).

**ILLICIUM** Linn. (*Magnoliaceae*)

D.E.P., IV, 331 ; Fl. Br. Ind., I, 40.

A small genus of evergreen aromatic shrubs or small trees, distributed in Atlantic North America and Asia. Two species occur in India.

*I. griffithii* Hook. f. & Thoms. is a large shrub, 3-4½ m. high, found in Bhutan and Khasi hills at altitudes of 1,400–1,700 m. Leaves ovate, elliptic-lanceolate ; flowers solitary, axillary or terminal ; fruits consisting of compressed, beaked, incurved carpels (follicles) arranged in a single whorl ; seeds small, sub-rotund, slightly compressed, glossy, brown.

The fruit is slightly aromatic, with a bitter and astringent taste and is reported to be poisonous. It is stimulant and carminative. It yields, on steam-distillation, an essential oil resembling that from aniseed (*Pimpinella anisum* Linn.) and fennel (*Foeniculum vulgare* Mill.) [Dymock, Warden & Hooper, I, 40–41 ; Kirt. & Basu, I, 60 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6**(2), suppl., 10 ; Chopra & Badhwar, *Indian J. agric. Sci.*, 1940, **10,** 17].

*I. verum* Hook. f. constitutes the source of Star Anise oil used as a flavouring agent and in medicine. It does not occur in India, but its fruits (Star Ainse of China ; Hindi *Anasphal, sonf* ; Tel.— *Anaspuvu* ; Tam.- *-Anashuppu, anasi-pu* ; Bombay *-Badian*) are imported from China and Indo-China ; data relating to imports are not available.

FIG. 105. ILLICIUM GRIFFITHII—FLOWERING BRANCH & FRUIT

FIG. 106. ILLICIUM VERUM—FRUITS AND SEEDS

*I. verum* is an evergreen tree attaining a height of 8-15 m. and a diameter of *c.* 25 cm. Leaves entire, 10-15 cm. long and 2.5–5 cm. broad, elliptic to oblanceolate ; flowers solitary, white to red in colour ; fruit star-shaped, consisting of 8 carpels (follicles) arranged in a whorl around a short central column : each follicle 12–17 mm. long, boat-shaped, hard and wrinkled, containing a seed ; seeds brown, compressed-ovoid, smooth, shiny, brittle. The plant is indigenous to tropical and subtropical east Asia. It is extensively cultivated in a limited area with particular ecological factors, in Kwangsi in south-east China and Tonkin in Indo-China.

Star anise tree is propagated by seeds, sown in beds in October-November. The seedlings are transplanted, at the fourth leaf stage, first in a nursery and again, after 3 years, in the plantation. The plant comes into bearing from the tenth year onwards. The fruits are generally collected before they are quite ripe, when the essential oil content is maximum. The average life of the tree is 80–100 years.

The bulk of harvested fruits is steam-distilled in the fresh condition for the essential oil; the rest is dried for export (*Bull. econ. Indoch.*, 1938, **41,** 966; Schmidt & Marcus, II, 370; Guenther, V, 363-65).

Star anise fruit has an agreeable, aromatic, sweet taste and a pleasant odour resembling anise. It is used as a condiment for flavouring curries, confectionery and spirits, and for pickling; it is also used in perfumery. The fruit is chewed to sweeten the breath and to help digestion. It is stomachic and carminative, and considered useful in flatulence, spasmodic affection of the intestinal canal, and dysentery. It is used as an adjunct to cough mixtures and as a corrective of taste [Burkill, II, 1225; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, **6** (2), suppl., 10; Parry, J. W., 130; Hill, 453; Dymock, Warden & Hooper, I, 40].

Star anise fruit is often adulterated with the fruit of *I. anisatum* Linn. syn. *I. religiosum* Sieb. & Zucc., grown in Japan and variously known as Japanese sacred anise tree, Poison bay, Shikimi or Shikimi-noki, False aniseed and Bastard star anise. The fruit of *I. anisatum* is poisonous (Wehmer, I, 338; Krishna & Badhwar, loc. cit.; Youngken, 307; Guenther, V, 378–79; Wallis, 249; U.S.D., 1955, 1721).

Star anise oil of commerce is obtained by the steam-distillation of fresh fruits of *I. verum* (yield, 3-3.5%). It is colourless or pale yellow with the characteristic odour and aromatic taste of true anise oil (from *Pimpinella anisum*); the odour and taste of the latter are rather more delicate. The oil has the following characteristics: sp. gr.$^{20°}$, 0.978–0.987; $n_D^{20°}$, 1.5530-1.5582; .77° to +0.57°; congeal. pt., 15.0-18.4°; sol. in 1.0–2.5 vol. of 90% alcohol; anethole is the chief constituent (85-90%). Star anise oil is official in the pharmacopoeias of many countries; it constitutes the bulk of the Oil of Anise of commerce (Guenther, V, 367-76; Int. P., I, 158; U.S.D., 1955, 92).

Star anise oil is used as a flavouring agent in confectionery, candy, chewing gum, tobacco, animal feeds, liqueurs and pharmaceutical preparations. It is used also in perfumery and soaps. The oil is stimulant, stomachic, carminative, mildly expectorant and diuretic. It relieves colic and is an ingredient of cough lozenges. The oil is employed as an application in rheumatism and otalgia, and as an antiseptic. It is considered useful against body lice and bed bugs, and forms an ingredient of cattle sprays. It is used in favus (honeycomb ringworm) and scabies. The oil enters into the composition of a number of official preparations (Guenther, V, 376; Kirk & Othmer, IX, 576; Schmidt & Marcus, II, 371; *Chem. Abstr.*, 1947, **41,** 3576; Wren, 332; B.P.C., 1949, 567; Nadkarni, I, 676; U.S.D., 1955, 92; Steinmetz, I, 46).

Decorticated seeds contain a fatty oil (55%) having the following constants: sp. gr.$^{25°}$, 0.9128; $n_D^{25°}$, 1.4677; sap. val., 194.5; iod. val., 88.36; acid val., 11.65; acetyl val., 8.37; R.M. val., 0.75; Polenske val., 0.29; and unsapon. matter, 0.59%. The component fatty acids of the oil are: myristic, 4.43; stearic, 7.93; oleic, 63.24; and linoleic, 24.4% (Airan & Shah, *J. Indian chem. Soc.*, 1942, **19,** 175).

Star anise plant is used for flavouring foods and confectionery and is considered useful for colic, constipation and insomnia. The Chinese are reported to prepare a medicinal tea from the leaves (Burkill, II, 1226).

**ILLIGERA** Blume (*Hernandiaceae*)

Fl. Br. Ind., II, 460.

A genus of scandent shrubs distributed in the tropics of the Old World. Three species occur in India.

*I. appendiculata* Blume syn. *I. coryzadenia* Meissn. is an extensive climber, up to 80 ft. high, occurring in Khasi hills and along streams and in damp places in the Andaman Islands. Leaves trifoliolate: leaflets (2–5 in. × 0.5-1.5 in.), very variable, oblong, elliptic or sub-orbicular, entire, obtuse or abruptly acuminate; flowers white (with pink calyx lobes) in lax pendulous cymes; fruit 2-winged, sparsely tomentose. In Penang, the leaves are reported to be used as poultice for boils (Burkill, II, 1226).

*I. villosa* C. B. Clarke is a tawny villous climber with pink flowers and often 3-winged fruits, occurring in the hills of Assam. It is reported to be used as a febrifuge (Fl. Assam, IV, 105).

**Ilmenite** — *see* **Titanium Ores**

**IMPATIENS** Linn. (*Balsaminaceae*)

A very large genus of more or less succulent, annual or biennial herbs, rarely becoming shrubby or epiphytic. They are chiefly natives of the mountainous regions of tropical Asia and Africa but are also found in the north temperate zone and in S. Africa. About 150 species occur in India. Many of them are endemic and show restricted distribution in certain regions. Only *I. balsamina* is common throughout the country [Hooker, *Rec. bot. Surv. India*, 1904–06, **4**(1–3), 1].

A large number of *Impatiens* species have been

acclimatised and grown in gardens and green houses for their showy blossoms. They are mostly annuals flowering in summer and are excellent for planting in beds or along borders. Forms yielding double-flowers (Camellia flowered) or spotted or striped flowers have been evolved by breeding and selection (Bailey, 1947, I, 442 ; II, 1642 ; Chittenden, I, 232).

Balsam plants thrive in rich, friable, well-drained soil, in open sunny situations and need a liberal supply of water during growth. They flower profusely and capsular fruits, when ripe, dehisce explosively and shatter the seeds. The best sowing time in the plains of N. India is June-July, about the commencement of the monsoon, while on the hills, they can be sown by the end of March; in S. India, they can be grown nearly throughout the year. Seeds germinate readily ; seedlings are raised in nurseries or in boxes and transplanted in prepared beds. Biennial and perennial forms may be propagated from cuttings. To obtain best results, side branches are pinched out so that large blooms appear on the main axis (Firminger, 596 ; Gopalaswamiengar, 439 ; Burns & Davis, 26 ; Bailey, 1947, I, 442 ; II, 1642 ; Chittenden, II, 1047).

**I. balsamina** Linn. GARDEN BALSAM

D.E.P., IV, 334 ; Fl. Br. Ind., I, 454.

SANS.—*Dushpatrijati* ; HINDI—*Gulmendhi* ; BENG. —*Dupati* ; MAR.—*Terada* ; GUJ.—*Gulmendi*, *pantambol* ; TAM.—*Kasittumbai* ; MAL.—*Mecchingom* ; ORIYA—*Haragaura*.

PUNJAB—*Bantil*, *trual*, *halu*, *tatura*, *tilphar*, *juk*.

An erect, branched succulent annual with shortly stalked or stalkless, alternate, lanceolate, serrate leaves ; flowers solitary or fascicled, purple, pink or nearly white, with long, slender, incurved spurs ; fruits capsular, hairy ; seeds globose, tubercled, about 0.5 cm. in diameter.

This species is found nearly throughout the tropical and sub-tropical parts of India and is found growing gregariously as forest undergrowth. It is very variable and many forms, often separated as varieties, are cultivated in gardens (Hooker, loc. cit. ; Firminger, 596).

The seeds of garden balsam are edible. They contain c. 27.0% of a green viscous oil with the following constants: $n^{30°}$, 1.5070 ; sap. val., 188.13 ; iod. val. (Wij's), 177.4 ; R.M. val., 1.9 ; and unsapon. matter, 0.9%. The presence of $\beta$-amyrin, $\alpha$-spinasterol and balsaminasterol (m.p., 160.1°) has been reported in the unsaponifiable matter. The mixed fatty acids of the oil are: palmitic, 4.68 ; stearic, 5.76 ; arachidic, 2.80 ; oleic, 18.30 ; linoleic, 9.17 ; linolenic, 30.15 ; and parinaric, 29.14% ; the occurrence of parinaric acid (a tetra-ethenoid $C_{18}$ acid) distinguishes this oil from other fatty oils. The oil may be used for cooking and for burning in lamps ; it is also suitable for use in the surface-coating industry (Sarkar & Chakrabarty, *Sci. & Cult.*, 1955–56, **21,** 616 ; *Chem. Abstr.*, 1942, **36,** 7337 ; 1954, **48,** 13835).

Alcoholic extracts of the flowers possess marked antibiotic activity against *Sclerotinia fructicola*, *Colletotrichum lindemuthianum* and other pathogenic fungi and bacteria. The active principle has been identified as 2-methoxy-1, 4-naphthoquinone (Little *et al.*, *J. biol. Chem.*, 1948, **174,** 335).

The deep red flowers contain a monoglycosidic anthocyanin based on pelargonidin, whereas the roots and stems contain cyanidin monoglycoside (Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B,** 211).

In Bali, the leaves are eaten. The flowers and, at times, the leaves too are reported to be used as a substitute for henna (*Lawsonia inermis* Linn.) for dyeing finger nails (Burkill, II, 1228).

The plant is said to resemble, in its medicinal properties, *I. pallida* Nutt. and *I. nolitangere* Linn., found in America and Europe, the acrid juice of which is considered emetic, cathartic and diuretic. In Philippines, the leaves of *I. balsamina* are used in poultices. The flowers are mucilaginous and cooling and used for lumbago and intercostal neuralgia ; they are reported to improve circulation and relieve stasis. In China, powdered seeds are prescribed for difficult labour (Kirt. & Basu, i, 446 ; U.S.D., 1947, 1488 ; Quisumbing, 555).

**I. chinensis** Linn.

Fl. Br. Ind., I, 444 ; Fyson, I, 86 ; II, Pl. 63.

TAM.—*Vashtla*, *pylee* ; MAL.—*Pily*.

A variable succulent annual, with glabrous angled stems, found up to 5,000 ft. in Bhutan, Khasi hills, Aka and Lushai hills, Manipur, hills of Orissa, eastern ghats, western ghats south of Konkan, and Nilgiris. The flowers which are rose purple to white in colour, with slender incurved spurs, appear in July.

The plant is used as an external application to burns ; it is taken internally with milk in gonorrhoea (Rama Rao, 59 ; Kirt. & Basu, I, 447).

**I. glandulifera** Royle, non Arn. syn. *I. roylei* Walp
ROYLE'S OR HIMALAYAN BALSAM

D.E.P., IV, 336 ; Fl. Br. Ind., I, 468 ; Blatter, I Pl. 17, Fig. 2.

A variable handsome bush, 4–10 ft. high, distributed from Kashmir to Nepal and common in Himalayas up to 9,500 ft. Flowers pale pink or crimson, sometimes white, with a short spur; capsule clavate, glabrous, usually drooping; seeds large, broadly obovoid, with opaque spongy testa. The plant is hardy and makes rapid growth when planted in gardens. It flowers during August–September.

The seeds are edible and possess a nutty taste. They contain: moisture, 6.5; protein, 20–22; and fatty oil, 50%. The oil is highly refractive and can be used as a semi-drying oil. It is not, however, available in any quantity for commercial use. The difficulty appears to be that plants ripen unevenly and seeds are scattered violently from ripe capsules and cannot be collected easily. The oil is light to golden yellow in colour, with an agreeable taste; in odour it is similar to wood oil. It possesses the following characteristics: $n_D^{20°}$, 1.5300; sap. val., 230–245; iod. val. (by hydrogenation), 218–245; diene val., 32–52; and unsapon. matter, 1%. The fatty acids present are: parinaric, 42; oleic, linoleic and linolenic, 42; saturated acids (chiefly stearic and palmitic), 6–12; and acetic, 9–10%. The oil has an unusual composition in that it contains acetic acid and parinaric acid. The oil dries and thickens under heat faster than linseed oil. Varnishes prepared from the oil dry well but are somewhat inferior to linseed oil varnishes in durability (*Chem. Abstr.*, 1950, **44**, 1265; 1949, **43**, 134; Jordan *et al.*, 51, 74).

**I. holstii** Engl. & Warb. = *I. walleriana* Hook. f.
HILL BALSAM

Chittenden, II, 1048.

A fleshy herb or undershrub, 2–3 ft. high, with scarlet flowers introduced from Africa and grown in gardens. It resembles *I. sultani* Hook. f. and grows vigorously under cultivation putting forth perpetual blooms of large and bright flowers. A hybrid with *I. sultani*, known as *I. holstanii*, is also cultivated in gardens (Gopalaswamiengar, 440).

The flowers of this plant contain pelargonidin complex 3:5-dimonoside, closely resembling monardaein; the bluish rose flowers of another variety of this plant contain peonidin complex 3:5-dimonoside (Robinson & Robinson, *Biochem. J.*, 1932, **26**, 1657).

**I. sulcata** Wall. syn. *I. gigantea* Edgew. GROOVED BALSAM

D.E.P., IV, 336; Fl. Br. Ind., I, 469; Blatter, I, Pl. 17, Fig. 1.

A gigantic annual, 4–10 ft. high, with stout, grooved stems, frequent in the temperate Himalayas from Kashmir to Sikkim up to an altitude of 12,000 ft. It bears pink, purple or dark crimson flowers. The seeds are eaten and an oil is extracted from them; the properties of the oil have not been investigated. The seed husks are reported to be eaten raw in Lahul (Kanny Lal Dey, 163).

**I. tingens** Edgew. syn. *I. racemosa* Hook. f. (Fl. Br. Ind.), non DC.

D.E.P., IV, 335; Fl. Br. Ind., I, 479.

A small herbaceous plant with peculiar white or pink flowers, common in temperate Himalayas, from Kumaon to Sirmore at altitudes of 5,000–10,000 ft. and extending eastwards to central Nepal. It occurs in shady damp ravines and flowers during August–September. The seeds are edible and yield an oil used for burning in lamps (Hooker, loc. cit.).

**I. tripetala** Roxb. syn. *I. multiflora* Wall.

Fl. Br. Ind., I, 470.

LAKHIMPUR–*Karya bijal, dam doka.*

An annual herb with long-stalked leaves and purple flowers, found in tropical Himalayas, Sikkim, Bhutan, Assam and Khasi hills up to 3,000 ft. The juice of the root mixed with milk, is reported to be given in haematuria [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 393; Kirt. & Basu, I, 447].

The seeds of *I. amphorata* Edgew., *I. amplexicaule* Edgew., *I. scabrida* DC., and a few other western Himalayan species are reported to be edible.

*I. parviflora* DC. (SMALL BALSAM), an erect annual, 1–3 ft. high, with small, pale pink or white flowers, occurs in Kashmir at an altitude of 3,500–8,000 ft. It is a native of Siberia and Turkestan. The leaves of the plant contain vitamin C (c. 25 mg./100 g.) and can be used as salad. The seeds contain over 50% oil which is suitable for use in lacquers (Hooker, loc. cit.; *Chem. Abstr.*, 1950, **44**, 242; *Food Sci. Abstr.*, 1951, **23**, 263; *Chem. Abstr.*, 1949, **43**, 134).

## IMPERATA Cyr. (*Gramineae*)

A small genus of perennial grasses found throughout the tropical and subtropical regions of the world. One species occurs in India.

**I. cylindrica** Beauv. syn. *I. arundinacea* Cyr.
THATCH GRASS

D.E.P., IV, 336; III, 423; Fl. Br. Ind., VII, 106; Hubbard, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 5.

SANS.—*Darbha*; HINDI—*Dabh, siru, ulu*; BENG.—*Ooloo, ulu*; TEL.—*Balbajamu, barhisan, darbha gaddi*; TAM. *Dharbai pul, inankapillu, nanal, varli-pillu*; KAN.—*Sanna dabbai hullu*; MAL.—*Vidulam*.

PUNJAB—*Dab, kusa, sil, sir*; UTTAR PRADESH—*Bharavai, sil, siru, usirh*; RAJASTHAN—*Khans*; MADHYA PRADESH—*Chitra, dab, gondi, lotan, phulya, pottar*; BOMBAY—*Dhub*; ASSAM *Batta, khair, ullu*; SANTAL & KOL—*Chero*.

A very variable, tufted, perennial grass with rhizomatic underground parts; rhizomes white, somewhat succulent, branched, extensively creeping, scaly; culms erect, ranging from slender, filiform, dwarf forms 7.5–10 cm. high to stout, robust forms about 2.8 m. tall and 8 mm. in diam.; leaves variable, very short to 1.5 m. long, erect, linear to linear-lanceolate, flat; panicle silver-white, dense, fluffy, silky, cylindrical 2.5–22.5 cm. or more (rarely 75 cm.) in length; grains (caryopsis) small, elliptic to oblong brown, light, loose.

FIG. 107. IMPERATA CYLINDRICA—FLOWERING PANICLES

*I. cylindrica* is distributed throughout the tropical and temperate regions of the Old World and in parts of temperate South America. It is common in tropical Africa, southern Europe and eastwards to Turkestan, Afghanistan, India, Ceylon, Malaya, Java, China, Japan and Australia. It has been introduced into U.S.A. and is found in Florida. In India, it is found throughout the hotter parts, both in plains and hills, ascending up to 2,300 m. in the Himalayas.

Five varieties of *I. cylindrica* are distinguished: var. *major* (Nees) C.E. Hubbard, var. *latifolia* (Hook. f.) C.E. Hubbard, var. *africana* (Anderss.) C.E. Hubbard, var. *europae* (Anderss.) Aschers. & Graebn., and var. *condensata* (Steud.) Hack. These varieties are found in definite geographical regions. Of these, var. *major* and var. *latifolia* occur in India. The former exists in two habital forms, viz. depauperate and savannah. The depauperate form with minute filiform culms, 7.5–10 cm. high, small leaves and panicles, is common in lawns and areas subject to continual cutting or grazing. The savannah form is strongly gregarious with stout culms, 0.9–1.2 m. high, long and broad leaves and long panicles. Var. *latifolia* occurs in swamps and marshes in the northern part of Uttar Pradesh. It attains a height of 2.8 m. or more, with leaves 1.2 m. long and panicles up to 60 cm. in length. This variety is considered by some authorities as a distinct species (Hubbard, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 9–12; Hole, *Indian For. Mem., For. Bot. Ser.*, 1911, **I**, 91; Bor., *Indian For. Rec., N.S., Bot.*, 1940, **2**, 144).

*I. cylindrica* grows gregariously in low-lying swampy grounds, water-logged areas, bunds of rice fields and sides of irrigation channels. It is common on sandy loams in coconut and sal plantations and is capable of withstanding great variations in temperature and also drought. It is essentially a light-loving plant, growing in open spaces; it is found as an undergrowth in tropical forests where there is not much of shade. The grass is often found in association with *Saccharum munja* Roxb. and *Erianthus ravennae* Beauv. (Hubbard, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 7; Gray, ibid., No. 7, 1944, 18–23; Hole, loc. cit.; Bor, loc. cit.).

The grass spreads rapidly by seeds and by rootstocks. The seeds, which are very light, are carried by wind to new situations. Once established, the grass multiplies rapidly by rootstocks. The savannah form

flowers in the hot season, the swamp form, at the close of rains or in cold season; and the depauperate form, irregularly almost throughout the year. The rootstocks are extremely resistant to destruction by fire; occasional firing is believed to stimulate shooting and flowering (Brown, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 18; Gray, ibid., No. 7, 1944, 19; Hole, loc. cit.; Bor, loc. cit; Singh & Guha, *Indian For. Bull.*, No. 145, 1951; Raitt, *Indian For. Rec.*, 1913, **5**, 74).

*I. cylindrica* is a troublesome weed infesting cultivated fields and plantations in eastern tropics, especially Malaya, Java and Ceylon. It is ubiquitous and is always one of the first to cover newly opened lands. It affects plantation crops, like rubber, tea, coconut, quinine, teak, fig and oil-palms. It obstructs re-afforestation by suppressing seedlings of other plants. Once established, eradication becomes exceedingly difficult and expensive. The weed inhibits nitrogen accumulation in the soil thereby affecting soil fertility. It also serves as a cover for injurious animals and trombiculid mites which transmit scrub typhus. The roots tend to choke subsoil drains used in anti-malarial operations. Areas infested with this grass are believed to constitute breeding grounds for locusts [Gray, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 24–26; Burkill, II, 1229; Buckley, *Malay. agric. J.*, 1951, **34**(4), 27].

*Eradication*—Various methods—mechanical, cultural and chemical—have been tried for eradicating the weed. Partial control is effected by grazing, burning, scything and rolling. Flooding infested lands with water is also reported to be effective as a control measure. Complete eradication has been made possible by repeated shallow ploughing under certain conditions. Deep digging to remove rootstocks is laborious and expensive. Frequent deep ploughing of infested areas followed by disc-harrowing, exposes the rootstocks to sun, when they die out; this treatment diminishes soil fertility due to exposure and wash; further, the method cannot be applied in areas with standing tree crops. Mechanical eradication should be followed by cultivation of cover crops in order to prevent the weed from regeneration (Gray, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 45–47, 51–53; *Peradeniya Manual*, Dep. Agric. Ceylon, No. 7, 1951; Tempany, *World Crops*, 1951, **3**, 143; Buckley, loc. cit.; *World Crops*, 1953, **5**, 287).

The grass may be eradicated by planting quick-growing cover or shade crops, such as *Centrosema pubescens* Benth., *Pueraria* sp., *Mimosa invisa* Mart., *Dolichos hosei* Craib, *Crotalaria* sp., *Tephrosia* sp., and *Indigofera* sp.; prolonged shade kills the weed. An associated advantage of growing shade crops is the improvement in soil. *Gliricidia sepium* Steud. has been tried in Ceylon with good results (Gray, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 48–50, 47; *For. Abstr.*, 1953, **14**, 450).

Various chemicals, e.g. copper sulphate, sodium arsenite and selective herbicides, have been tried to eradicate the weed. Sodium arsenite has been employed in rubber plantations in Malaya. Ten sprayings at the rate of 60 gal. of solution (1.6%) per acre, at intervals of 10 days, provide effective control; increased effectiveness is obtained by the use of a spreader, such as Teepol, along with sodium arsenite solution. In India, complete suppression has been effected by spraying sodium arsenite at the rate of 25 lb. per acre twice at an interval of 3 weeks. Areas treated with sodium arsenite should be isolated and straying animals warded off. Application of Atlacide (sodium chlorate 94%), a non-poisonous chemical (160–240 lb. in 160–360 gal. of water per acre) is reported to be effective. Other chemicals, suggested for control of the weed are: Cornox 'D' (32% amine salt of 2,4-D) applied in 10% aq. soln, Agroxone 3[30% MCPA (2-methyl-4-chlorophenoxy acetic acid)] in 5% aq. soln and 2,4,5-T in 10% emulsion in water; the weed is resistant to 2,4-D treatment. It succumbs to spraying by Sovacide, a mineral oil fraction, directly or in dilution with diesel oil or water. TCA (sodium tri-chloracetate) alone or in combination with sodium pentachlorophenate; and CMU [3-(*p*-chlorophenyl)-1, 1-dimethylurea] have also given satisfactory results. A modified method consists in mowing the grass to 10 cm. stubble, applying a contact herbicide, burning, and spraying 100 lb. of TCA per acre. Fumigation with chloropicrin kills rootstocks (Gray, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 47; *Plant. Chron.*, 1956, **51**, 293; Buckley, loc. cit.; *Gdn News Sheet, R. Agri. hort. Soc. India, N.S.*, No. 112, 1953, 3; *Rep. Bose Instt.*, 1953–54, 74; *Pesticides in Tropical Agriculture, No. 13 of Advances in Chemistry Series*, 90, 92; *Hort. Abstr.*, 1955, **25**, 584).

*Utilisation*—*I. cylindrica* has been tried in India as a raw material for paper pulp. It is inferior to sabai grass (*Eulaliopsis binata* C.E. Hubbard); the pulp is short-fibred (av. length of fibre, 1.26 mm.), weak and difficult to bleach; it can be used in admixture (up to 10%) with long-fibred pulp. Tests carried out in Malaya and elsewhere show that long-fibred pulp with good felting properties may be prepared from the grass growing in those areas; the pulp compares

favourably with that from Algerian esparto grass (*Stipa tenacissima* Linn.) but slightly inferior to that from Spanish esparto grass; it yields a strong opaque paper which does not shrink on drying. The grass has been used for the commercial production of paper pulp in Australia and New Guinea. The grass should be cut before or during flowering, because considerable lignification takes place during the maturation of the seed. The yield of the dry grass in India has been estimated at 1.7 tons per acre per annum under a two year rotation (Raitt, loc. cit.; Singh & Guha, *Indian For. Bull.*, No. 145, 1951; *Indian For.*, 1952, **78**, 348; Tempany, *World Crops*, 1951, **3**, 143; *Bull. imp. Inst., Lond.*, 1937, **35**, 311).

Analysis of Indian grass gave the following values (dry basis): water sol., 8.85; pectose (with fat and wax), 26.76; lignin, 9.91; cellulose, 54.48; and ash, 4.09%. Digestion with caustic soda (19%) for 5 hr. (at 153° and 60 lb./sq. in. pressure) gave a yield of 41% unbleached pulp and 35% bleached pulp. The fractional soda process was more economical for pulping than the mono-sulphite process; optimum results were obtained by 1½ hr. digestion at 138°, the consumption of caustic soda in the digestion liquor (40 g./litre), calculated on the basis of air-dry raw material, being 6%, and of bleaching powder (35% available chlorine), being 4.0%. The yields were: unbleached pulp, 43.8% and bleached pulp, 40.2%; the bleached pulp was of bright shade (Raitt, loc. cit.; Singh & Guha, loc. cit.).

Mature leaves of *I. cylindrica* are coarse and are not relished by cattle; the saw-like edges are known to cause sores. Tender and succulent shoots, produced after burning the field, are palatable to stock. Analysis of tender grass gave the following values (dry matter basis): crude protein, 6.56; ether extr., 3.33; crude fibre, 34.6; N-free extr., 47.6; ash, 7.92; calcium, 0.39; nitrogen, 1.05; and phosphorus, 0.22%; starch equivalent, 10.7; and digestible protein, 0.8 lb./100 lb. Nitrogen balance is negative. It is reported to be a good source of vitamins A and C. Feeding experiments on young and adult animals show that the grass at any stage of growth produces acidic urine. Adult animals fed on mature or partially mature grass are likely to suffer from acidosis (Hole, loc. cit.; Brown, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 27–33; Talapatra, *Indian J. vet. Sci.*, 1950, **20**, 183; Teik, *Sci. Ser. Dep. Agric. Malaya*, No. 24, 1951, 84).

*I. cylindrica* is a good soil binder for railway embankments, river banks, dams and coastal sand dunes. It is suitable for the reclamation of dry and desert areas. Leaves of *I. cylindrica* make a good and durable thatch; considerable areas are set apart in the tea gardens of Assam for growing this grass. The grass is used for making ropes, brushes, mats and cowry bags, for plait work and weaving into baskets and plates. It is also used as packing material. The depauperate form is used as lawn grass in northern India. In South China, dried grass is employed as fuel. Together with stems of elephant grass (*Pennisetum purpureum* Schum.), it is used for firing pottery in Uganda. The flossy inflorescence is used for stuffing cushions and pillows (Brown, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 38, 43–44; Tadulingam & Venkatanarayana, 327; Bor, loc. cit.; Badhwar, *Indian For.*, 1946, **72**, 64; Hole, loc. cit.; Dalziel, 530).

Rhizomes of *I. cylindrica* are eaten by pigs. A sugar is prepared from the rhizome after eliminating the bitter constituents present in aqueous extracts of the rhizome by adsorption with diatomaceous earth. A kind of beer is said to be prepared in Malaya by the fermentation of rhizome infusion. Analysis of rhizomes gave the following values (dry basis): total sugar, 22.05; reducing sugar, 9.20; and invert sugar, 12.45% (Hole, loc. cit.; Burkill, II, 1231; *Chem. Abstr.*, 1952, **46**, 10325).

The grass provides a mulching material for some crops; the mulch breaks down to a manure when treated with Adco. In a few cases, the grass may have a favourable effect, either directly or indirectly, on the cultivated crop. In Sumatra, the burning of the grass in infested tobacco fields eliminates the weeds which are susceptible to slime disease (*Pseudomonas solanacearum*) and thereby indirectly benefits tobacco. Likewise, in the Philippines, the development of the sugarcane parasite, *Aeginetia indica*, is prevented by the grass, though elsewhere, the grass itself has been reported to be susceptible (Brown, *Jt Publ. imp. agric. Bur.*, No. 7, 1944, 44; Gray, ibid., No. 7, 1944, 26; Burkill, II, 1231).

The rhizomes of *I. cylindrica* are used in China as a restorative, tonic and antipyretic, and in Cambodia, as a fumigant for piles. A decoction of rootstocks is given for diarrhoea, dysentery and gonorrhoea. In the Philippines, fruiting spikes are considered sedative when taken internally. The seeds are used as vulnerary to stop bleeding (Burkill, II, 1232; Quisumbing, 99).

**Inchigrass** — *see* **Cymbopogon**

**Indian Arrowroot** — *see* **Hitchenia**

**Indian Butter Bean** — *see* **Dolichos**

**Indian Butter Tree** — *see* **Diploknema, Madhuca**

**Indian Cork Tree** — *see* **Millingtonia**

**Indian Corn** — *see* **Zea**

**Indian Crab Apple** — *see* **Docynia**

**Indian Doum Palm** — *see* **Hyphaene**

**Indian Eagle-Wood** — *see* **Aquilaria**

**Indian Fig** — *see* **Opuntia**

**Indian Napellus** — *see* **Aconitum**

**Indian Shot** — *see* **Canna**

**India Rubber** — *see* **Ficus**

**Indicolite** — *see* **Tourmaline**

**Indigo** — *see* **Indigofera**

**Indigo, Assam** — *see* **Strobilanthes**

**INDIGOFERA** Linn. (*Leguminosae*)

A very large genus of herbs, shrubs or undershrubs, distributed in the tropical and sub-tropical regions of the world, especially in Africa. About 54 species have been recorded in India; some of them are cultivated for the dye, indigo; many are grown for fodder and green manure and as plant cover.

Several species of *Indigofera* yield a blue colouring matter, used since early times, for dyeing purposes. Natural indigo was an important dyestuff exported from India until the end of the last century; its importance has declined with the advent of the synthetic product. In 1896–97, nearly 16,88,900 acres were under indigo cultivation and the production of dye was 1,68,700 cwt.; the corresponding figures for 1955–56 were 10,600 acres and 2,600 cwt. (Table 1). Of the various species exploited for the dye, the chief ones in India were *I. arrecta, I. suffruticosa, I. sumatrana* and *I. tinctoria*. Of these *I. arrecta* was the most important, particularly during World Wars I and II, when due to the shortage of the synthetic dyestuff, indigo cultivation received a brief stimulus. *I. arrecta* was preferred because of its higher dye content than other species and was grown in Bihar, the dye extracted in factories equipped with steam power and marketed under strict supervision. *I. sumatrana* was the species grown in Madras; the total acreage under the crop in the State was larger than that under any *Indigofera* species in any other State. Even at present, *I. sumatrana* is grown over a large area in Madras State and used for green manuring purposes. Since 1949, the acreage and production of indigo has further dwindled due to the diversion of areas to food and other remunerative crops. At present large areas are devoted to this crop only in Andhra Pradesh and Madras (Davis, *Agric. J. India* 1918, **13**, 32, 206; 1919, **14**, 21; *Handbook of Commercial Information for India*, 1937, 329).

The colouring matter of the plant, indigotin ($C_{16}H_{10}O_2N_2$; m.p., 390° decomp.), is present in the form of a glucoside, indican ($C_{14}H_{17}O_6N$: m.p., 176–78°), particularly in the lamina and to a small extent in the midribs or rachis. The indigotin content varies in different species; it also varies according to the season and age of the plant. The dye is extracted from the leaves by fermentation when indican hydrolyses into glucose and indoxyl ($C_8H_7ON$; m.p., 85°): the latter on oxidation yields indigotin.

Natural indigo contains, in addition to indigotin, varying proportions of a red dye, indirubin; a resinous impurity, indigo brown; indigo-gluten; and other substances. The indigotin content of different grades of natural indigo are as follows: best grades, 70–90; medium grades, 40–50; and low grades, *c.* 20%. Analysis of a sample of good Bengal indigo gave: indigotin, 61.4; indirubin, 7.2; indigo brown, 4.6; indigo-gluten, 1.5; mineral matter, 19.6; and moisture, 5.7% (Thorpe, VI, 432-39; Perkin & Everest, 475-516).

For the extraction of indigo, what is known as the

TABLE 1—AREA UNDER CULTIVATION AND PRODUCTION OF DYE IN INDIA

| | Area (1,000 acres) | Production of dye (1,000 cwt.) |
|---|---|---|
| 1896–97 | 1,688.9 | 168.7 |
| 1913–14 | 127.6 | 26.8 |
| 1918–19 | 292.0 | 48.6 |
| 1929–30 | 75.7 | 14.4 |
| 1934–35 | 59.6 | 10.2 |
| 1939–40 | 38.3 | 5.3 |
| 1943–44 | 57.1 | 9.0 |
| 1948–49 | 30.0 | 4.9 |
| 1953–54 | 11.7 | 1.2 |
| 1954–55 | 11.1 | 2.7 |
| 1955–56* | 10.6 | 2.6 |

* Includes Andhra Pradesh, 4,975; Madras, 4,900; Bombay, 483; Mysore, 251; Others, 33 acres.

wet process is almost universally adopted. In this process, freshly harvested plants are steeped in water in specially constructed vats; the water is warmed if necessary to 32°. Fermentation sets in and the glucoside breaks down by the action of indimulsin, naturally present in the plant, to glucose and indoxyl. The fermentation is completed in 10–15 hr. The yellow liquor is run into beating (oxidising) vats equipped with paddle wheels; when the wheels are rotated, the liquor is thrown up into the air as a fine spray and the indoxyl gets oxidised to indigo, which settles down as a fine blue mud at the bottom of the vat. The supernatant water (the seeth water) is then drawn off. Better yields are obtained by fermenting the leaves under acid conditions and effecting oxidation by blowing ammonia, steam and air simultaneously into the fermented liquor by means of an injector. Addition of sodium nitrate or *Dhak* gum (from *Butea monosperma*) facilitates the settling of indigo mud. The oxidised product is stirred with boiling water containing a little dilute sulphuric acid, allowed to settle and the clear liquor decanted; it is then washed with boiling water, filtered through cloth and pressed. The product is cut into 3 in. cubes and air-dried to *c.* 6% moisture. The cubes are brushed to remove surface mould growth, if any, polished and packed in wooden chests. The average yield of indigo is 25% of the total extractable colouring matter.

A small quantity of indigo is manufactured in Madras by a modified process known as the dry process. The leaves are air-dried prior to steeping in water; they are then macerated with water in a vat and fermented for about 2 hr. The fermented liquor is treated in the same manner as that described under the wet process. The advantage of the dry process lies in the short duration of fermentation; further the indigo obtained is reported to be more uniform. However, some loss of indigo may occur during the air-drying of leaves thereby resulting in lower yields (Thorpe, VI, 432-39; Nicholls & Holland, 388–91; Davis, *Agric. J. India*, 1918, **13**, 32, 206; *Agric. Res. Inst. Pusa, Indigo Publ.*, No. 1–11, 1918–22; Marsden, *Bull. Dep. Agric., Madras*, No. 74, 1918; Ghosh, *Sci. & Cult.*, 1943-44, **9**, 487, 537.)

The cubes of indigo are graded and priced in the trade on the basis of specific gravity, colour, nature of fracture, porosity and appearance when the surface is scratched with the finger nail. High grade indigo has a deep violet blue shade and when scratched with the finger nail, shows a coppery lustre; it is light and porous. Indigo of inferior quality contains much soluble and mineral matter; it is heavy, hard, and dull grey in colour; it does not show a coppery lustre when scratched.

Natural indigo was being marketed in the form of 3–3½ in. cubes. The grades commercially known were the Bihar or Bengal cake and the Oudh and Benares cake in Calcutta and the *Kurpah* cake in Madras. The bulk of the Bihar production was exported to U.K. and Europe, while that of Madras was sent to Egypt and Japan. During 1918–1923, the Government of India levied a cess on indigo exports and utilised the proceeds to promote scientific research on the cultivation and manufacture of indigo (*Handbook of Commercial Information for India*, 1937, 329; *Mem. Dep. Agric. Madras*, No. 36, 1954, 686).

Indigo finds use in dyeing and printing cotton and rayon, and for dyeing wool. It has been employed in the preparation of pigments for paints, lacquers, rubber, and printing inks. It is used also to a small extent by artists and in wall paper decoration. It possesses excellent fastness to light and washing; dyeings on wool are faster than those on cotton. In vat dyeing, the indigo is reduced to leuco indigo or indigo white, which forms a yellow solution in alkaline liquors. When the fabric is dipped in the liquor, it absorbs indigo white and on exposure, the blue dye is formed on the fabric by oxidation. As leuco indigo has a low affinity for cotton, a succession of dips are required to build up the required shade (Kirk & Othmer, VII, 814; Heaton, 175; Thorpe, XI, 851).

The residual parts of plants left after the extraction of the dye are rich in available nitrogen and are used as manure for cereals, oilseeds, sugarcane and tobacco. They contain: nitrogen (as $NH_3$), 1.2; potassium (as $K_2CO_3$), 0.89; and phosphorus (as $H_3PO_4$), 0.27%. The seeth water from beating vats yields on evaporation a residue containing: nitrogen, 2.77; mineral matter, 25.90; volatile acids, 21.04; succinic acid, 2.18; brown matter, 12.03; and indigotin, 0.1%; it is used as manure (Atkins, *Sci. Progr.*, 1921–22, **16**, 56; Howard & Howard, *Bull. agric. Res. Inst. Pusa*, No. 54, 1915, 11; *Chem. Abstr.*, 1945, **39**, 2651; Perkin & Everest, 504).

**I. anabaptista** Steud.

Fl. Br. Ind., II, 102.

A small annual with spreading branches, thinly covered by white hairs, found in the plains of western India, in Punjab and U.P. Leaves pinnate, with 3–7

leaflets ; flowers tiny, in short racemes of 15–20 ; pods linear and reflexed, 6–8 seeded.

The plant is recommended as a green manure. Analysis of leaves gave the following values: nitrogen (N), 4.21 ; phosphoric acid ($P_2O_5$), 0.71 ; potash ($K_2O$), 2.85 ; and lime (CaO), 4.89% (Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362).

**I. arrecta** Hochst. NATAL INDIGO, JAVA INDIGO, BENGAL INDIGO

C.P., 661 ; A Manual of Green Manuring, 72, 123.

An erect, deep green, leafy undershrub, 3–6 ft. high, with imparipinnately compound leaves, 4–5 in. long: leaflets 7–8 pairs with one odd terminal leaflet ; flowers small, pinkish red, in axillary racemes ; pods straight and reflexed.

The plant is indigenous to Abyssinia and was introduced into India through Java. Its cultivation was popular in Tirhut, Saran and Champaran districts of N. Bihar, Patna, Gaya, Shahabad and parts of Chota Nagpur in S. Bihar, and parts of U.P. The seeds of *I. arrecta* possess hard coats and unless specially treated before sowing, show poor germination. They are usually scarified in a machine or treated with concentrated sulphuric acid and sown in lines, on well ploughed, manured and levelled soil. Sowing is done in the middle of October in Bihar, at the rate of 6–8 lb. of seed per acre. The crop cannot tolerate more than two months of constant moisture in the soil ; so seeds are sown after the rains, mixed with a cold weather cover crop, such as mustard or wheat. With the advent of warm weather and harvest of cover crops, the indigo crop makes rapid growth and is ready for the first cut by the end of May or the beginning of June. The plants are cut about 1 in. from the ground and a second crop is taken after an interval of six weeks or more depending upon the conditions. Unlike *I. sumatrana*, *I. arrecta* matures earlier and withstands submersion under water. It yields heavily ; with superphosphate manuring yields of 30,279–82,115 lb. of green matter per acre have been reported. The recorded output of indigo cake per acre from two different areas in Bihar were 137.8 lb. and 228.66 lb. when *I. arrecta* was grown, as against 32.14 lb. and 68.32 lb. respectively from the same areas when *I. sumatrana* was cultivated (Howard & Howard, *Bull. agric. Res. Inst. Pusa*, No. 51 & 54, 1915 ; Davis, *Agric. J. India*, 1918, **13**, 32, 206 ; 1919, **14**, 21).

FIG 108 INDIGOFERA ARRECTA—FLOWERING & FRUITING BRANCHES

In Bihar, the plant is affected by a wilt which causes serious damage. The incidence is observed after the first cut, when due to floods, the soil gets water-logged. Wilting can be checked by pruning, soil aeration, and application of organic manure and soluble phosphates (Howard *et al.*, *Mem. Dep. Agric. India, Bot.*, 1920, **11**, 1 ; Ghosh, *Sci. & Cult.*, 1943–44, **9**, 487 ; Davis, *Agric. Res. Inst. Pusa*, *Indigo Publ.*, No. 7, 1).

*I. arrecta* has been tried as a cover crop in coffee, tea and rubber plantations and as a green manure crop for rice ; it has been specially recommended in rotations before cotton. It grows vigorously and stands lopping better than *Crotalaria* spp. Analysis of the leaves gave the following values: nitrogen (N), 4.46 ; phosphorus ($P_2O_5$), 0.02 ; potassium ($K_2O$), 1.95 ; and calcium (CaO), 4.48% (Dalziel, 245 ; Whyte *et al.*, 361 ; A Manual of Green Manuring, 123 ; Use of Leguminous Plants, 211 ; Krumbiegel, 76 ; Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362).

*I. arrecta* produces seeds in large quantities and their germination is generally uniform and good. In the early years when *I. arrecta* was introduced into Bihar, it was observed that plants grown for leaf did not produce sufficient seeds for sowing the next crop. Seeds had to be imported specially from neighbouring states like U.P. and Assam. It was later found

that the seed production was poor in plants which had been cut once or twice for leaf, and in order to obtain sufficient supply, the crop had to be raised exclusively for seed. For seed purposes, sowing is best done in the middle of August, in lines 24 in. apart, and the crop is left uncut till the seeds are fully mature. Under favourable conditions, a yield of 600-800 lb. of seeds per acre has been obtained in Bihar; in Assam, yields up to 1,200 lb. per acre have been recorded. Seeds can be stored in gunny bags in a dry place, until required for sowing (Howard & Howard, *Bull. agric. Res. Inst. Pusa*, No. 51 & 54, 1915; Howard *et al.*, *Mem. Dep. Agric. India, Bot.*, 1920, **11**, 1; Davis, *Agric. Res. Inst. Pusa, Indigo Publ.*, No. 8, 1921; Atkins, ibid., No. 10, 1921).

The yield of leaves from *I. arrecta* is higher than that from any other species of *Indigofera*; the indigotin content of the plant (0.8-1.0%) is also higher than that of other species. The leaves contain up to 4% of a flavonol glycoside, kaempferitrin ($C_{27}H_{30}O_{14}$: m.p., 201-03°), which on hydrolysis yields rhamnose and kaempferol (Davis, *Agric. J. India*, 1918, **13**, 206; Mayer & Cook, 183; Perkin & Everest, 502).

**I. articulata** Gouan syn. *I. argentea* Linn. var. *caerulea* Baker (Fl. Br. Ind.); *I. caerulea* Roxb. SURAT INDIGO, WILD INDIGO, EGYPTIAN INDIGO, ARABIAN INDIGO

D.E.P., IV, 383; C.P., 662; Fl. Br. Ind., II, 98.

SANS.—*Kalaklitaka*; HINDI—*Surmainil*; TAM.—*Kataveri*; TEL.—*Karunili*; KAN.—*Karunili*.

MARWAR—*Nil*.

An erect shrub with silvery white stems and short-petioled leaves, distributed in western India, Deccan and parts of Bihar. Leaves 2–3 in. long: leaflets 3-9, argenteo-canescent on both surfaces; flowers in short-peduncled or subsessile racemes; fruits thick, turgid, recurved. This species is indigenous to India and was probably the source of indigo in early days, particularly in Gujarat. It was introduced into Arabia, Egypt and other Mediterranean countries where it became the source of the dye (Burkill, 1909, 22).

The plant has been tried as a source of green manure for paddy. Mixed cropping trials with sunn hemp carried out in the rice fallows of Bapatla (Andhra State) gave a yield of 4,000-6,000 lb. of green matter per acre. The seeds were treated before sowing with hot water for 10 min. to remove the wax covering on the surface. Air-dried seeds, mixed with sunn hemp, were broadcast at the rate of 60 lb. per acre, 3 or 4 days before the harvest of paddy. The indigo plants were allowed to grow after the harvest of sunn hemp for fodder and ploughed into the soil in May. The green matter thus ploughed in contained (per acre) an equivalent of 40 lb. of nitrogen. Analysis of the plants gave the following values: nitrogen (N), 1.8; phosphoric acid ($P_2O_5$), 0.2; potash ($K_2O$), 0.6% (Rao, *Andhra agric. J.*, 1954, **1**, 103; *Mem. Dep. Agric. Madras*, No. 36, 1954, 837).

The seeds are sometimes used as famine food. The roots and leaves of the plant are bitter and tonic; the seeds are considered anthelmintic (Kirt. & Basu, I, 716).

**I. aspalathoides** Vahl ex DC. WIRY INDIGO

D.E.P., IV, 384; Fl. Br. Ind., II, 94; Kirt. & Basu, Pl. 296.

SANS.—*Ratakohomba, sivanimba*; TAM.—*Iraivanvembu, sivanar vembu*; KAN.—*Nila, sivamballi*; MAL.—*Manali*.

A low undershrub with copiously spreading, terete branches and argenteo-canescent branchlets, found in the Deccan, plains of Carnatic and Ceylon. Leaves digitate: leaflets 1–5, pale green, oblanceolate with a few adpressed hairs; flowers red; pods straight, glabrous, turgid, 6–8 seeded.

The leaves, flowers and tender shoots are cooling and demulcent; they are used in the form of decoction for leprosy and cancerous affections; the leaves are also applied to abscesses. The root is chewed in toothache and aphthae. The whole plant is used in applications for oedematous tumours and the ashes are used in preparations for dandruff (Kirt. & Basu, I, 710).

The plant is an ingredient of an oily preparation used for syphilitic and other skin affections; a decoction of the plant is given as an alterative in secondary syphilis; trials have, however, shown that it does not possess any of the properties attributed to it (Koman, 1918, 20; 1920, 6).

**I. cordifolia** Heyne

D.E.P., IV, 385; Fl. Br. Ind., II, 93.

MARWAR—*Vekriavas*; BOMBAY—*Godadi, bodaga, botsaka*; GWALIOR—*Nilabari*.

A copiously branched diffuse annual, found throughout India. Leaves simple, sub-sessile, cordate or ovate; flowers bright red, 4–8 on copious heads; pods generally 2-seeded.

The plant comes up at the commencement of monsoons on medium to fallow soils in Bombay; seeds ripen in November. The white seeds, which resemble poppy, are threshed out and used in mixture with

bajra or jowar for making bread; consumed alone, they are reported to be harmful. The type of *I. cordifolia* found in the Deccan is considered to be a good forage [Gammie, *Rec. bot. Surv. India*, 1902, **2,** 179; Patil, *Indian Fmg, N.S.*, 1957–58, **7**(4), 24].

**I. endecaphylla** Jacq. TRAILING INDIGO

Fl. Br. Ind., II, 98.

An annual or biennial trailing herb with stems 1–2 ft. long, distributed in the hills of Deccan, western ghats and Nilgiris, up to 6,000 ft. Leaves nearly sessile, with 5–9 membranous leaflets; flowers violet purple, in close peduncled racemes; pods deflexed, glabrous, c. 1 in. long, containing 6–10 seeds.

This plant is grown as a cover and green manure crop in coffee, tea and new rubber plantations. It is not affected by any serious disease or pest and thrives well at high altitudes with heavy rainfall. It prefers a clayey soil, but also gives good cover on sandy soil. It tolerates a certain amount of shade and stands pruning; it is also drought-resistant. It provides an excellent cover in protecting the soil from erosion. It is tolerant to acid and also to phosphorus deficiency in soil and can be propagated by seeds or cuttings. Seed production is generally poor: seeds have a hard coat and germination is poor unless the coat is softened by treatment with 40% sulphuric acid (Whyte *et al.*, 280; A Manual of Green Manuring, 86; Use of Leguminous Plants, 211; Grist, 66, 202; Mudaliar, *Madras agric. J.*, 1953, **40,** 309; Gandhi, *Indian J. agric. Sci.*, 1957, **27,** 131; Paul, *Trop. Agriculturist*, 1952, **108,** 191).

Used as green manure, it enriches the nitrogen and organic matter contents of the soil. A yield of 1.6–2.4 tons per acre of green material from plants two months old has been reported from the Philippines;

*F.R.I., Dehra Dun. Photo: M. Bakshi*

FIG. 109. INDIGOFERA ENDECAPHYLLA—COVER CROP IN YOUNG SAL PLANTATION

FIG. 110. INDIGOFERA ENDECAPHYLLA—FRUITING BRANCH

this corresponds to 28.72 lb. of nitrogen and 0.56 tons of dry matter. From six months old plants, the yield per acre is 10.24 tons, corresponding to 206.9 lb. of nitrogen and 5.08 tons of dry matter. Analysis of the fresh plant gave the following values: moisture, 74.7; organic matter, 22.1; ash, 3.2; and nitrogen, 0.78% (Use of Leguminous Plants, 23, 211).

The crop is readily eaten by cattle, but it does not stand heavy grazing. In Indo-China, a yield of 6–18 tons of green fodder per acre has been recorded. Analysis of the leaves and stems gave the following values: water, 80.5; protein, 4.1; fat, 0.6; soluble carbohydrates, 7.9; fibre, 4.7; and ash, 2.2%; digestible nutrients: protein, 3.1; fat, 0.4; soluble carbohydrates, 6.4; and fibre, 2.8%; nutritive ratio, 3.3; starch equivalent, 12.9 lb/100 lb. The leaves and stems constitute a rich source of vitamins A and C. However, reports from Hawaii and some other regions show that the plant is toxic. Used as pasturage in mixture with grasses, or fed green or in a semi-dry state after chopping, it caused abortion in cows and heifers; it caused also anorexia, loss of weight and emaciation. The toxic principle is reported to be identical with hiptagenic acid ($\beta$-nitropropionic acid, $C_3H_5O_4N$; m.p., 68°), which is also toxic to chicks (lethal dose for one week old chick, 5 g. of dry plant material) (Use of Leguminous Plants, 212; Burkill, II, 1238; Dalziel, 246; Nordfeldt *et al.*, *Tech. Bull. Hawaii agric. Exp. Sta.*, No. 15, 1952, 5–22; Teik, *Sci. Ser. Dep. Agric. Malaya*, No. 24, 1951, 68, 83; Morris *et al.*, *Science*, 1954, **119**, 322; McIlroy, 21).

**I. enneaphylla** Linn.

D.E.P., IV, 385; Fl. Br. Ind., II, 94; Kirt. & Basu, Pl. 295.

SANS.—*Vasuka*; HINDI—*Latahai*; GUJ.—*Bhonyagali*; MAR.—*Bhingule*; TAM.—*Sheppunerunji*; TEL.—*Yerrapalleru, chalapachhi, cheragaddam*; KAN.—*Kenneggilu*; MAL.—*Cherupullate*.

A small trailing, much-branched annual or biennial, distributed throughout India in the plains and up to 4,000 ft. in the Himalayas. Leaves nearly sessile, 7–11 foliolate; flowers red, 10–20, in sessile or short-peduncled spicate heads; pods thinly hairy, cylindrical with 2 globose seeds.

The plant is relished by cattle. In Trinidad, it is grown in association with grasses in paddocks and gardens, and subjected to regular grazing. Recent trials in Australia have shown that the plant is toxic to horses, causing incoordination of gait, violent tetanic spasms and haemorrhage in nostrils; the toxicity is greatly reduced when the material is chopped and dried. The plant contains two unsaturated hydrocarbons, indigoferin ($C_{70}H_{110}$; m.p., 77°) and enneaphyllin ($C_{90}H_{151}$; m.p., 98°) in the ratio of 3 : 1 (Duthie, I, 251; Paul, *Trop. Agriculturist*, 1951, **107**, 225; Bell & Everist, *Aust. vet. J.*, 1951, **27**, 185, 189; 1952, **28**, 141; Chatterji & Dutt, *Proc. nat. Inst. Sci. India*, 1937, **3**, 371).

The plant has been recommended as a green manure. Analysis of the leaves gave the following values: nitrogen (N), 3.26; phosphoric acid ($P_2O_5$), 0.53; potash ($K_2O$), 2.32; and lime (CaO), 1.85% (Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362).

The juice of the plant is reported to be antiscorbutic, diuretic and alterative. The plant is boiled with oil and applied to burns. A decoction is given in epilepsy and insanity (Kirt. & Basu, I, 710; Rama Rao, 108).

**I. galegoides** DC.
Fl. Br. Ind., II, 100.

A tall shrub, up to 15 ft. in height, with twiggy branches distributed in Bihar, Khasi hills and Kerala. Leaves with distinct petioles; racemes dense, 2–3 in. long; flowers pale red; pods 2.5–3 in. long, with 15–18 seeds.

This species was formerly cultivated in Java with *Tectona grandis* as a cover crop. The fresh plant, on steam-distillation, yields 0.2% of a light yellow volatile oil (sp. gr., 1.046) with the odour of bitter almonds and a herbaceous aroma. The oil contains: benzaldehyde, hydrocyanic acid and small amounts of ethyl and methyl alcohols (Use of Leguminous Plants, 213; Gildemeister & Hoffmann, II, 612).

**I. gerardiana** Wall. ex Baker HIMALAYAN INDIGO
D.E.P., IV, 385; Fl. Br. Ind., II, 100; Collett, Fig. 36.

PUNJAB—*Kati, khenti, mathu, kutz, shagali, katsu*; SIMLA—*Kathi, theot, kathu.*

A low, copiously branched shrub with short-petioled leaves, found in temperate and sub-tropical Himalayas at altitudes of 2,000–12,000 ft. Flowers bright red or rosy, in distinctly peduncled racemes; pods 1½–2 in. long, sub-cylindrical, glabrous, 6–10 seeded. The plant is often gregarious in secondary scrub forests, especially in old clearings. It is also found associated with banj (*Quercus incana*), blue pine (*Pinus excelsa*) and spruce (*Picea morinda*). In dry exposed conditions, the size of the plant is much reduced. It affords shelter to tree seedlings in hill slopes. A variety of this plant, var. *heterantha*, is found as far east as Bhutan and Khasi hills ascending to 8,000 ft. (Osmaston, 151; Parker, 132).

The twigs of the plant are used for basket work and for making rope bridges. The wood is white and hard, with an irregular heartwood of dark colour. The plant is reported to yield a fodder of medium value (Gamble, 230–31; Laurie, *Indian For. Leafl.*, No. 82, 1945, 9).

**I. glandulosa** Willd. BEFRI
D.E.P., IV, 386; Fl. Br. Ind., II, 94.

GUJ.—*Vekhariyo*; MAR.—*Bargadan*; TEL.—*Baragadam, barapatalu, barapatam, boomidapu.*

DECCAN—*Barbada, metikasa.*

An annual herb, hairy when young, found in U.P., Bihar and the plains of Deccan. Leaves trifoliolate, distinctly petioled: petioles as long as the leaflets; racemes sessile; flowers small, red with exserted corolla; pods brown, finely pubescent with 1–2 reddish seeds.

The plant is variable; it is a common weed in the dry and sandy soils of the Deccan, Gujarat and other places. Four or five types of the plant have been recognised, of which one is late maturing in the Deccan; this type is drought-resistant, leafy and palatable to cattle. By cultivation and selection, plants bearing 2–3 seeded pods have been raised. Individual seeds of cultivated plants are nearly twice the size of seeds from wild plants. From a collection of 100 selected plants, 86 lb. of seeds were obtained (Krumbiegel, 50; Patil, *Poona agric. Coll. Mag.*, 1956–57, **47**, 73).

The seeds of the wild plant resemble ragi (*Eleusine coracana*) and are sometimes used as famine food. They are nutritive and contain about three times as much protein as wheat; the nutritive value is improved by cultivation. Analyses of wild and cultivated seeds gave the following values: *wild seeds* moisture, 8.2; protein, 31.9; fat, 2.2; carbohydrates, 46.7; fibre, 7.8; and ash, 3.2%; *cultivated seeds*—moisture, 8.15; protein, 37.06; fat, 4.89; carbohydrates,

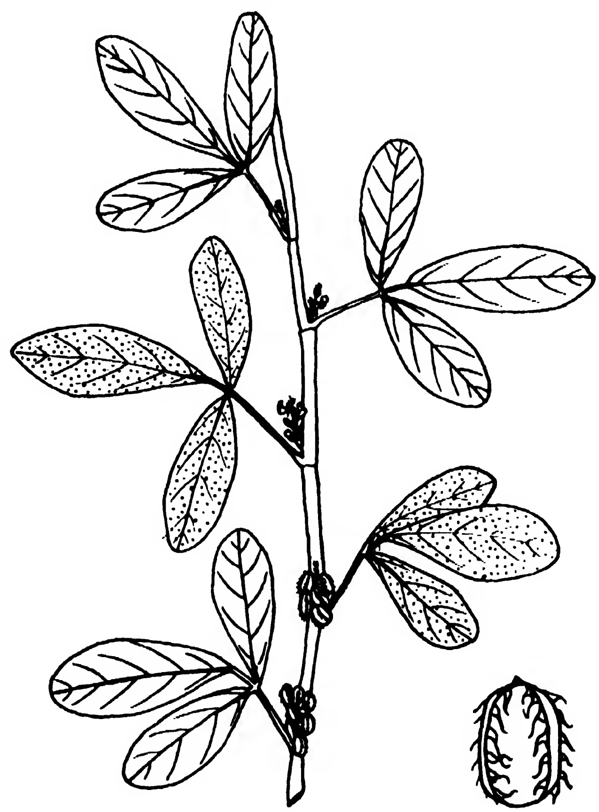

FIG. 111. INDIGOFERA GLANDULOSA—FLOWERING & FRUITING BRANCH

36.05; fibre, 9.28: and ash, 4.12%. The seed proteins have a high digestibility coefficient (83%) and their biological value is about equal to that of pulse proteins (Krumbiegel, 51–52: Gammie, *Rec. bot. Surv. India*, 1902, **2**, 179; Kirt. & Basu, I, 709; Bose & Subramanian, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953–54, **3**, 66).

The plant provides forage for cattle, particularly when cultivated in good soil and in well-drained localities. It is highly palatable in the green condition when cut before flowering. The plant has also possibilities for use as green manure. It gave a yield of 8,260 lb. of green matter per acre when cut before flowering (Burns *et al.*, *Bull. Dep. Agric. Bombay*, No. 78, 1916, 20: Chavan & Patil, *Poona agric. Coll. Mag.*, 1952–53, **43**, 70).

**I. hirsuta** Linn. HAIRY INDIGO
Fl. Br. Ind., II, 98.

An annual or biennial herb, 2–6 ft. high, with grey or brownish pubescence, found throughout India in the plains and up to an elevation of 4,000 ft. in Kumaon. Leaves short-petioled, 2–5 in. long with 5–11 large obovate leaflets: flowers red or pink, in dense axillary racemes; pods ½–¾ in. long, densely pubescent, pointing downwards.

*I. hirsuta* thrives on poor sandy soils and is not affected by any serious diseases and pests. It has a spreading habit and provides ample leafy material. It is not, however, considered to be as satisfactory as *I. endecaphylla* for cover or green manure as its recovery after lopping is uncertain. It has been tried as a cover crop for citrus in U.S.A.: sown in spring at the rate of 4–8 lb. of seed per acre, it gave a yield of about 15,000 lb. of green matter per annum. In India, a yield of 8,000 lb. of green matter per acre has been reported in coconut gardens on the west coast. The manurial constituents present in the leaves are as follows: nitrogen (N), 2.14; phosphoric acid ($P_2O_5$), 0.29; potash ($K_2O$), 1.84; and lime (CaO), 4.25% (Whyte *et al.*, 280: A Manual of Green Manuring, 72; Use of Leguminous Plants, 213; Burkill, II, 1238; *Bull. Indian Cocon. Comm.*, 1955–56, **9**, 83; *Hort. Abstr.*, 1953, **23**, 165: Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362).

The plant is an important constituent of pastures and can yield a forage of good quality; it can also be grown pure. It should be cut early so that it may not become coarse. Analysis of hay from plants cut at the flowering stage shows the following values: moisture, 10.68; crude protein, 13.65; crude fat, 1.41; N-free extr., 46.04; fibre, 21.00; and ash, 7.22%; *digestibility co-efficients:* dry matter, 62.5; protein, 67.0; fat, 61.0; N-free extr., 67.0; and fibre, 53.5%; *digestible nutrients:* total digestible nutrients, 53.15; and digestible protein, 9.14%; starch value (Kellner), 40.13%; and nutritive ratio, 4.8 (Whyte *et al.*, 280; *Chem. Abstr.*, 1945, **39**, 2356).

FIG. 112. INDIGOFERA HIRSUTA—FLOWERING & FRUITING BRANCH

The plant has been reported to be toxic, in some cases, to cattle. The skin on the legs becomes swollen, scabby, cracked and often bleeding; whether this is due to mechanical injury or due to other factors or a combination of both is still uncertain. Ointments containing sulpha drugs may be applied to the affected parts to facilitate healing (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 88; West & Emmel, *Bull. Fla agric. Exp. Sta.*, No. 510, 1952, 56).

*I. hirsuta* is reported to be the source of indigo dye in W. Africa. A decoction of the leaves is employed,

in Ghana (Gold Coast), as a lotion for yaws and, in Philippines, for diarrhoea and as stomachic (Dalziel, 247 ; Quisumbing, 407).

**I. linifolia** Retz.

D.E.P., IV, 386 ; Fl. Br. Ind., II, 92 ; Kirt. & Basu, Pl. 293.

HINDI—*Torki* ; BENG.—*Bhangra* ; GUJ.—*Jhinkigali, nahanigali* ; MAR.—*Bhangra.*

BOMBAY—*Bhangra, burbura, daniu, ameliu, pandharipale, torki* ; DELHI—*Leel, sankhahuli* ; SANTAL—*Tandikhodebaha.*

A slender, trailing or procumbent herb covered by silvery pubescence, distributed throughout the plains of India. Leaves simple, linear : flowers in 1–8 flowered, short, sub-sessile, racemes ; pods globose, silvery white, hard and one-seeded.

The plant is mentioned as a fodder for cattle, although cattle do not appear to relish it. Under cultivation, the plant assumes a more or less erect form and a yield of c. 10,000 lb. green fodder per acre has been reported. In Sudan, the plant is known to grow luxuriantly in patches during the hot months, maintaining goats in good condition and in milk. The seeds are reported to be collected and used as famine food (Gammie, *Rec. bot. Surv. India*, 1902, **2,** 179 ; Burns *et al., Bull. Dep. Agric. Bombay*, No. 78, 1916, 22 ; Tothill, 865).

The plant is given in febrile eruptions. The Santals use the plant, along with *Euphorbia thymifolia* Linn., for amenorrhoea. It is also considered to have vermifuge properties. Alcoholic extracts of the plant contain an unsaturated lactone, linifolin ($C_{26}H_{50}O_2$ ; m.p., 95–96°), a wax, tannins, phlobaphenes and glucose. The wax (0.02% on the wt. of the plant material ; m.p., 78–79° ; acid val., 11.87 ; sap. val., 49.78) contains ceryl palmitate and some higher melting point constituents (Kirt. & Basu, I, 708–09 ; Burkill, II, 1237 ; Gupta & Dutt, *Proc. nat. Acad. Sci. India*, 1938, **8,** 49 ; Warth, 211).

**I. oblongifolia** Forsk. syn. *I. paucifolia* Delile

D.E.P., IV, 386 ; Fl. Br. Ind., II, 97 ; Kirt. & Basu, Pl. 298.

SANS.—*Jhilla, mridupatraka, nila, raktapala* ; TAM.—*Kattukkarchammathi* ; TEL.—*Kondavempali.*

DELHI—*Jhungi, vilayati jhojun.*

A woody, branched undershrub, attaining a height of 4–6 ft., found throughout India growing even on the poorest of soils. Leaves argenteo-canescent : leaflets 3–7, oblong or oblanceolate : flowers tiny, bright red, with hairy corolla ; pod glaucous and distinctly torulose.

The plant is a good fodder for sheep. In Sudan, it is used as camel fodder. In S. India, it is used as green manure for wet lands (Tothill, 685).

The plant is antisyphilitic. The root is cooling, improves appetite, removes *vatarakta* and rheumatism. Boiled with milk, it is used as a purgative. All parts of the plant are useful in enlargements of liver and spleen. The stems are used as a gargle in mercurial salivations and for washing teeth (Kirt. & Basu, I, 712 ; Dalziel, 247 ; Burkill, 1909, 22).

**I. pulchella** Roxb. (Fl. Br. Ind.) in part.

D.E.P., IV, 387 ; Fl. Br. Ind., II, 101 ; Talbot, I, 382, Fig. 217.

HINDI—*Sakena, hakna* ; MAR.—*Baroli, chirmati, nirda* ; TAM.—*Narinji* ; TEL.—*Siralli, vuyye* ; KAN.—*Gogge* ; MAL.—*Manali* ; ORIYA—*Girili.*

SANTAL—*Dare huter, lilibichi* ; BIHI.—*Togri.*

A large shrub, 4–6 ft. high, found growing gregariously in moist evergreen forests throughout the Himalayan tract and on hills up to 5,000 ft. Leaves short-petioled : leaflets 13–21, thinly hairy, pale green above and glaucous below : flowers large, numerous, bright red to rose pink, in short peduncled racemes ; pods straight, 1–2 in. long, with broad sutures and 8–12 seeds.

The flowers of the plant are sometimes eaten in central India and Chota Nagpur. The loppings are used as fodder in Orissa. A decoction of the root is given by Santals for cough and its powder is applied externally for chest pains. The leaves and roots are used for swelling of the stomach (Laurie, *Indian For. Leafl.*, No. 82, 1945, 2 ; Kirt. & Basu, I, 714 ; Bressers, 43).

**I. subulata** Vahl ex Poir.

Fl. Br. Ind., II, 96.

A weak, perennial undershrub with subangular stems and long branches found growing among bushes on the hills of Krishna district, western ghats, Anamalais up to 3,000 ft. and in Coimbatore and Salem districts. Leaflets thin, glabrous above, pale below with a few adpressed hairs : flowers lilac red, in elongate racemes ; pods linear, slender, subtetragonal, curved outwards, 10–15 seeded.

The plant has been tried as a forage crop in East Africa and West Indies. It is similar in appearance and growth habit to *I. endecaphylla* and is resistant to drought and light frost. Analysis of the plant, when 6 weeks old, gave the following values (dry basis):

crude protein, 27.64; crude fibre, 13.93; calcium, 3.75; and phosphorus, 0.45% (Whyte *et al.*, 28; Guyadeen, *Trop. Agriculture, Trin.*, 1951, **28**, 231; Warmke *et al.*, *Agron. J.*, 1952, **44**, 517; Rogerson, *E. Afr. agric. J.*, 1954-55, **20**, 240).

**I. suffruticosa** Mill. syn. *I. anil* Linn. var. *polyphylla* DC. WEST INDIAN INDIGO, ANIL INDIGO

D.E.P., IV, 383; C.P., 661; Bailey, 1947, II, Fig. 1958.

HINDI *Vilaiti nil*; TAM.—*Shimaiyaviri*; TEL.—*Shimanili*; KAN.—*Shimenili*.

A perennial shrub attaining a height of 3–6 ft., native of tropical America and West Indies, and introduced into India, Burma, China, Indo-China, Philippines, Java and other south-east Asian countries. Leaves 2–3 in. long, petioled: leaflets 5–15, opposite, obovate-oblong, glabrous above and pubescent below; flowers tiny, pale orange in colour, in short racemes of 15–20; pods curved, 0.3–0.6 in. long, 2–4 seeded, thickened at sutures. This species was tried as a substitute for *I. tinctoria* in Madras and Bombay, but is not known to be cultivated at present. In Java, it was tried in place of *I. sumatrana*, but rejected in favour of *I. arrecta* (Burkill, II, 1234; Nicholls & Holland, 384).

*I. suffruticosa* is hardy and can be grown on well-drained soil. It is propagated by seed, the seed rate being *c.* 10 lb. per acre. It is grown as a cover and green manure crop in coffee and tea plantations in Indonesia, Malaya, Ceylon and Africa. The plant contains: moisture, 74.7; ash, 3.2; and nitrogen (N), 0.78%. It is grown to a limited extent as a pasture plant in Hawaii (Burkill, II, 1239; Dalziel, 248; Whyte *et al.*, 281; Mukherji & Agarwal, *Bull. Indian Coun. agric. Res.*, No. 68, 1950, 6; A Manual of Green Manuring, 186; Use of Leguminous Plants, 210).

The plant is considered febrifugal, vulnerary, purgative, antispasmodic, diuretic and stomachic. It is given for syphilis and epilepsy. In French Guinea, bruised leaves are used as anodyne in warm baths; in decoction, they are sudorific. A decoction of roots and seeds is used for destroying vermin on human body and for urinary diseases and ulcers (Quisumbing, 408).

**I. sumatrana** Gaertn. syn. *I. tinctoria* (Fl. Br. Ind.) in part.

C.P., 661, 663; Fl. Br. Ind., II, 99 (in part).

HINDI & BENG.—*Neel*; TAM.—*Nili, avuri*; TEL.—& KAN.—*Nili*.

A stout shrub, 4–5 ft. high, introduced into India from Malaysia and cultivated in place of *I. tinctoria* in Bengal, Bihar, U.P., Punjab and Madras. Leaflets 9–15, obovate to nearly elliptic, 0.7–1.5 in. × 0.7 in.; racemes 3–6 in. long; pods somewhat obtusely curved, 1–1.25 in. long.

*I. sumatrana* was the principal source of indigo in Bihar and Bengal for a considerable period, but was eventually displaced by *I. arrecta*. In S. India, however, it continues to be cultivated; the chief areas of cultivation are: Cuddapah, Kurnool, Guntur, Nellore, Krishna and Godavari districts in Andhra Pradesh and S. Arcot and Chingleput in Madras (Burkill, II, 1239; Dalziel, 248; Davis, *Agric. J. India*, 1918, **13**, 200; *Mem. Dep. Agric. Madras*, No. 36, 1954, 683).

The seeds of *I. sumatrana* germinate readily and unlike the seeds of *I. arrecta* do not need any pretreatment. In Madras, where it is more commonly cultivated, it is sown during Dec.–Jan., generally as a dry crop, along with other crops like ragi, maize and gingelly. It is ready for cutting after 3 months and gives 2–3 cuttings taken at 2 months intervals. In the first cutting (*c.* 3 months after sowing), it yields about 9–10 thousand lb. of green material per acre and in the second cutting (*c.* 5 months after sowing) 10–12 thousand lb. The yield of indigo cake obtained ranges from 25–70 lb. as against 130–200 lb. per acre from Java indigo. This low yield is attributed to the low indigo content of the leaves (Davis, *Agric. J. India*, 1918, **13**, 206; *Bull. Dep. Agric., Madras*, No. 74, 1918, 11).

The plant is now grown mainly as a green manure crop, preceding cotton, maize or sugarcane. In Java, the yield of green material from 5 months old plants is reported to be about one ton per acre, corresponding to 97.3 lb. of nitrogen; the yield from one year old crop is 2.8 tons per acre, corresponding to 297.9 lb. of nitrogen (Use of Leguminous Plants, 210).

**I. tinctoria** Linn. (Fl. Br. Ind.) in part. COMMON INDIGO, INDIAN INDIGO

D.E.P., IV, 387; C.P., 662; Fl. Br. Ind., II, 99.

SANS.—*Nilla, nili, nilika, rangapatri*; HINDI & BENG. *Nil*; GUJ. *Gali, gari, nil*; MAR., TAM. & KAN. —*Nili*; TEL.—*Aviri, nili*; MAL.—*Nilam*.

A shrub, 4–6 ft. high, found nearly throughout India, mainly as an escape from cultivation. Leaves 1–3 in. long, with 9–13 leaflets; flowers red; pods glabrescent, slightly curved or straight, ¾–1 in. long. This species is very variable. It is considered to be

*Supt., Lalbagh Gardens, Bangalore*

FIG. 113. INDIGOFERA TINCTORIA—FRUITING BRANCH

Asian in origin, though it has been recorded as occurring wild in Africa. It was being cultivated in India, China and other countries of the east as the source of indigo, but was replaced first by *I. sumatrana* and *I. suffruticosa*, and later by *I. arrecta*.

The plant is not palatable to cattle: it is grown as a cover or green manure crop in coffee plantations and rice fields in South India. Analysis of the leaves gave the following values (dry basis): nitrogen (N), 5.11; phosphoric acid ($P_2O_5$), 0.78; potash ($K_2O$), 1.67; and lime (CaO), 5.35%. It is a rich source of potash, the ash (4.4%) containing as much as 9.5% of soluble potassium salts. The indigo refuse, obtained after dye extraction, gave on analysis: nitrogen (N), 1.8; phosphoric acid ($P_2O_5$), 0.4; and potash ($K_2O$), 0.3% (Yegna Narayan Aiyer, 613; Whyte *et al.*, 281; A Manual of Green Manuring, 100; Idnani & Chibber, *Sci. & Cult.*, 1952–53, **18**, 362; Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 4; *Mem. Dep. Agric. Madras*, No. 36, 1954, 837).

An extract of the plant is used in epilepsy and nervous disorders. The plant is used also in bronchitis and as an ointment for sores, old ulcers and haemorrhoids. The juice of the leaves is used for hydrophobia. In Cambodia, the leaves are given in decoction for blennorrhagia. The Mundas of Chota Nagpur use the roots for urinary complaints (Kirt. & Basu, I, 713).

**I. uniflora** Buch.-Ham.

Fl. Br. Ind., II, 94.

KAN.—*Kadu neeli.*

A perennial with slender branched stems, found in pastures and waste lands on the west coast from Konkan southwards to Kerala, and in parts of Coimbatore district during rainy months. Leaves small; leaflets 3–7, pale green, membranous; flowers small, solitary, red; pods straight, linear, glabrous, 4–7 seeded

This species is sometimes found growing gregariously in protected areas even on poor soils. It is relished by cattle and possesses high nutritive value. A yield as high as 5,850 lb. of green matter per acre, when cut in flower, has been reported for a self-sown manured plot. Analysis of the plant gave the following values (air-dry material): moisture, 9.56; crude protein, 12.26; ether extr., 2.46; crude fibre, 40.52; carbohydrates, 29.71; and ash, 5.49% (Narayana, *Madras agric. J.*, 1950, **37**, 259).

Besides the species dealt with above, *I. australis* Willd., *I. dosua* Buch.-Ham., *I. nummularifolia* (Linn.) Livera (syn. *I. echinata* Willd.) and *I. trifoliata* Linn. (Fl. Br. Ind.) in part, are useful fodder plants. The last named species (including *I. prostrata* Willd.) is found throughout India; an outturn of 6,000 lb. of green matter per acre in two cuttings has been reported from Poona. In feeding value, it is comparable to *I. glandulosa*. *I. australis* is reported to be cyanogenetic in Australia. The flowers of *I. dosua* are used in Kangra as pot-herb [Dalziel, 246; Burns *et al.*, *Bull. Dep. Agric. Bombay*, No. 78, 1916, 20; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 87; Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 64].

*I. zollingeriana* Miq. syn. *I. galegoides* Baker (Fl. Br. Ind.) in part non DC.; *I. teysmanni* Miq., a perennial quick growing shrub, at times reaching a height of 21 ft., has been introduced from Indo-China into India and Ceylon and has been tried as a shade tree in tea, coffee and cocoa plantations, and as a green manure crop in coconut groves. The plant is grown from seeds sown in the nursery and seedlings transplanted when *c.* 1½ ft. high. It starts flowering in about 9 months. A single plant, 3-year old, is reported to yield as much as 25 lb. of green material in a year. For use as shade plant, the lower branches are lopped off and trimmed (Whyte *et al.*, 281; *Cocon. Bull.*, 1957-58, **11**, 118; Paul, *Trop. Agriculturist*, 1953, **109**, 27).

*I. glabra* Linn. (syn. *I. pentaphylla* Linn.), *I. trita* Linn. f. and *I. trifoliata* are reported to possess medicinal properties. The leaves of *I. glabra* are used as a bitter tonic and febrifuge; it is used in external application as an emollient. The seeds of *I. trita* are considered nutritive, while those of *I. trifoliata* are given as a restorative along with other mucilaginous drugs (Kirt. & Basu, I, 717, 716, 711; Chopra, 498).

The twigs of *I. hebepetala* Benth., found in the Himalayas from Kashmir to Sikkim, at 6,000–15,000 ft. are used, like those of *I. gerardiana* var. *heterantha*, for basket work and rope bridges. *I. atropurpurea* Buch.-Ham. (including *I. hamiltonii* Grah.), which occurs from Punjab to Khasi and Garo hills in Assam, is used for similar purposes (Gamble, 231).

*I. parviflora* Heyne, a small, copiously branched annual, occurs in wet places in the plains of Carnatic and Deccan Peninsula. A yellow dye is said to be extracted from the plant in West Africa and employed for dyeing leather. *I. longeracemosa* Boiv., a slender shrub with woody branches occurs in the southern parts of Kerala and is reported to yield a dye (Dalziel, 247).

## INSECTS AND INSECT PESTS [Phylum *Arthropoda*, class *Insecta* (*Hexapoda*)]

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### General Characteristics and Distribution

Insects are generally accepted as the most dominant group of animals on the earth at present. Both as species and as individuals they far outnumber the combined total of the rest of the animal kingdom. Over a million species of insects have so far been named and it is believed they represent but a small fraction of the species still awaiting discovery. It is quite likely that in the geological past, a much larger number of insect species flourished, but many of them have become extinct. Some idea of the magnitude of the extinct forms may be gained from the fact that more than 12,000 species of fossil insects are already known, a number certainly large considering the frail nature of the body of insects.

The ancient Sanskrit literature of India contains numerous references to insects and the vital role they play in human economy. There is a good deal of mention in this literature of such familiar insects as honey-bee (*Madhu-makshika*), ants (*Pipilika*), species of *Xylocopa* and *Bombus* (*Bhramara*), in addition to flies, hornets, wasps, moths, glow worms, etc. Likewise, lac and silk insects have been known in India since very ancient times.

Insects are air-breathing arthropods (animals with jointed legs) with the body differentiated into three distinct regions, namely the head, the thorax and the abdomen. They are distinguished from the other air breathing arthropods like scorpions, spiders, mites, ticks, centipedes and millipedes by their single pair of antennae, paired compound eyes, three pairs of legs which are confined to the thorax and by their having two pairs (or sometimes one pair) of wings. Insects are indeed the only animals, other than bats and birds, which are capable of true flight. They vary much in size. Some of the insects, like the Indian *Mymar* which deposits its eggs inside the eggs of various aquatic insects, hardly measure 0.25 mm. long. Others, however, may be larger even than some of the smaller mammals; the fossil dragonfly, *Meganeura*, which flourished in the Middle Upper Carboniferous Epoch in many parts of the world, had a wing span of 700 mm. While some insects are dull and sombre coloured, many possess exceedingly brilliant colours, ranging from yellow, orange, red and blue to various combinations of these, and are often also iridescent. Many of the common insects are objects of exquisite beauty, colour and markings. Insects possess many complex sense organs. The sexes are separate and are often marked by very pronounced sex dimorphism (differentiation of form). Most insects are

oviparous, i.e. they lay eggs. Many species produce larvae without laying eggs, i.e. they are viviparous. Both parthenogenesis (reproduction without fertilization) and paedogenesis (reproduction by larvae and pupae) also occur in insects. Polyembryony (production of two or more larvae from a single egg) has been described in several species, some of which occur commonly in India. Their development is typically through metamorphosis.

The earliest insects in general were amphibiotic and had more or less prolonged larval life in water, with a comparatively brief aerial existence as sexually mature adults. The vast majority of the present day insects are, however, typically terrestrial, but many of them have secondarily taken to aquatic life. Insects occur everywhere on the earth, literally wherever life is just possible ; they are abundant in the tropics and temperate regions and also common in the ice of the arctic. They have been found even in hot and sulphur springs, deep wells and caves, glaciers and snow fields of the high mountain ranges of the world. Many are parasites on or inside plants and animals, including other insects. Some like the ants, the honey-bees and the termites are social insects and live in complex colonies, characterized by polymorphic castes.

Insects are capable of walking, running, climbing, burrowing or jumping on ground, skating on the surface of water or swimming and diving in water. On wings they can readily fly forwards, abruptly arrest movement and fly backward or sideways or even remain stationary in air, hovering on wings. They can take off vertically in flight from the ground. Some of them attain astonishing speeds in flight. Their strength and powers of endurance often seem incredible. The Indian stag-horn beetle, *Lucanus* sp., can, for example, haul an object, nearly a hundred times its own body weight, over a distance more than twenty times the body length, for almost half an hour without fatigue. The common flea with legs hardly a millimetre long can jump a horizontal distance of nearly 13 inches and a vertical height of 8 inches.

Insects may be said to be truly omnivorous. Their food includes nearly every type of organic matter, living or dead. Nothing is indeed neglected by them—not even the excreta of other insects.

Insects possess astonishing powers of reproduction and lay enormous numbers of eggs. They thus multiply extremely rapidly. Given favourable conditions, it is said that a pair of the common houseflies would, for example, produce in about six months a progeny of trillions of flies.

Insects have numerous enemies and also suffer from many fatal diseases caused by bacteria, fungi, protozoa, worms and various kinds of viruses. Insectivorous plants like the sundews (*Drosera* spp.) and bladderworts (*Utricularia* spp.) take a very heavy toll of insects, and insectivores, such as fishes, frogs, lizards, birds, rodents, pangolins and many other mammals, systematically hunt for insects as food. The worst enemies of insects, however, are insects themselves. At every stage of their development the insects are subject to attacks of one or more species of insect predators and parasites. But for this the insects would have multiplied to such an extent as to completely dominate the earth.

*Structure of the Body*

The organization of the body of insects is remarkable for its combination of minimum constructional material, maximum mechanical efficiency, great compactness, rigidity and strength of the skeleton, great flexibility, and extreme freedom of movement of parts and general plasticity. These characteristics are partly due to the small size of the body and partly due to the exoskeleton. Insects have no bones, but their body wall (integument) itself constitutes an effective external armour of hardened plates (sclerites), which are movably articulated together by means of flexible membranes. The exoskeleton consists of a cuticle secreted by the hypodermis derived from the ectoderm of the embryo. The cuticle is chemically composed of laminated layers of a complex protein, chitin-arthopodin. The integument has many external cuticular processes like hairs, scales and spines, and internally it is reinforced by ridges. There are also numerous glands which secrete substances like wax, scents, resins, fibres and moulting fluid. The reinforcement of the body wall by the non-elastic cuticle sets a limit to increase in the size of the body, so that the insect in its immature stages has to moult at intervals to attain its normal adult size. The integument has a thin water-proof coating of wax that prevents desiccation of the body fluids. It is also the chief seat of colours. The great variety of colours of insects fall into two groups: structural and pigmentary. The structural colours are due to light scattering, reflection, refraction and diffraction effects as a result of certain peculiarities in the minute structure of the integument. The pigmentary colours, on the other hand, result from some definite chemical substance, such as chlorophyll and melanin.

The exoskeleton forms typical rings one behind the

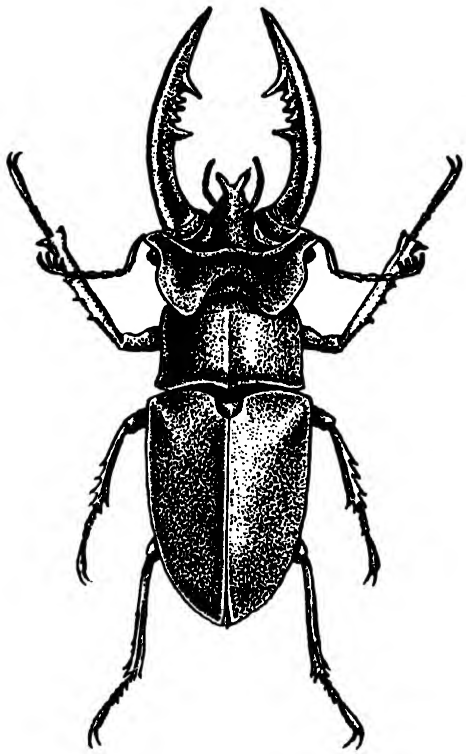


FIG. 114. STAG-HORN BEETLE (LUCANUS SP.), MALE (NAT. SIZE)

other, separated by membranous folds, so that the body of the insect is segmented. This segmentation is only external and the body cavity is unsegmented. Each segment is typically composed of a dorsal tergum and a ventral sternum connected at the sides by pleural membrane. The segments are heteronomous and are reduced, enlarged, consolidated or otherwise modified to form the three regions of the body. The head is composed of six body segments immovably fused together and greatly modified. The head bears the mouth parts, antennae, compound eyes and brain. The large size of the head in many insects is not due to the size of the brain, but to the powerful jaw muscles or the suction pump which helps insects to feed on liquids. The thorax which is the locomotor centre of the body both on the ground and in the air is composed of three body segments, namely prothorax, mesothorax and metathorax ; the proportions of these segments vary greatly. The legs are confined to the thorax and are often modified for walking, running, climbing, jumping, digging, scraping or tearing fibres, moulding wax, swimming, capturing prey, skating on the surface of water, clinging to hairs or feathers of host animals and for carrying loads during flight. The long-horned grasshoppers have ears (tympanal organs) on their front legs. Most insects have also special combs on the legs with which they clean the wings, antennae and other parts of the body. Wings are borne by the mesothorax and metathorax and the prothorax does not have wings in the present day insects. The wings of insects are lateral expansions of the body wall from the tergite of the thorax, reinforced by veins. Functional wings occur in adults only. The size, shape and texture of the wings differ widely. The fore wings are smaller and often modified into parchment-like or horny cases, quite useless in flight, but serving as protective covers for the membranous hind wings, which are much larger and used in flight. The wings are also variously clothed with setae (hairs) and scales, and patterned in different ways.

The abdomen of insects is often the longest part of their body. It is often more or less hidden under the wings. It differs from the head and the thorax in the absence of paired appendages. The visceral organs, like the major part of the alimentary canal, the heart and the excretory, circulatory and reproductive organs, are contained within the abdomen. The male and female external genital apertures are located at the end of the abdomen. The tip of the abdomen also bears clasping organs for use in copulation, and the ovipositor for egg laying.

The mouth parts, used as organs of ingestion, have three pairs of jaws: biting mandibles, the holding maxillae and the second maxillae fused into the lower lip or labium. Added to these are the anterior lip, the labrum, and internally the hypopharynx and the epipharynx.

Insects feed by different methods, depending largely on the nature of food. The mouth parts are, therefore, modified in different insects and include the following main types: biting and chewing: rasping and sucking ; piercing and sucking ; sponging ; siphoning ; chewing (or cutting) and lapping. The biting-chewing type of mouth parts is found in grasshoppers and termites. The rasping-sucking type of mouth parts is found in thrips in which the right mandible is reduced : the left mandible, maxillae and hypopharynx are elongate and move out through an opening in a cone-shaped head. The piercing-sucking type of mouth parts is seen in various bugs, like the common bed-bug. The labrum and labium, in this type, are elongated to form a rostrum or beak, containing the long needle-shaped stylets, which are the modified mandibles and lacinia of the maxilla. The

maxillary stylets form the food channel. The mouth parts of the common housefly constitute the typical example of the sponging type. The labium, here, is modified into a soft, elbowed rostrum, ending in a haustellum, bearing a labella. The labellar surface is grooved by the so-called pseudotracheae. These insects sponge the liquids from moist surfaces. The siphoning type of mouth parts, found in butterflies, comprises a long coiled proboscis, composed of the elongated galea of the maxilla. The mandibles are absent. The tip of the proboscis is capable of piercing the skin of nectaries of flowers and sucking up the liquids through the food channel formed between the galeae. The chewing-lapping type of mouth parts is typical of the honey-bees. The mandibles are short and toothless. The galea of the maxilla is elongated into sword-like lancets which help in puncturing the nectaries of flowers. The glossa of the labium is elongated into the tongue with which the honey-bee laps off the nectar.

*Development*

The eggs of insects are variable in size, shape and markings and are usually deposited either directly on or in the immediate vicinity of the food of the future larvae. The number of eggs laid by an insect is usually very large. Some species lay between 2,000 and 3,000 eggs per day and continue at this rate for several weeks or even years. The queen termite lays over a million eggs during her life time. Rarely, as in the aphids, the female lays but a single fertilized egg in her life.

The eggs are rich in yolk, which is mostly concentrated in the centre of a peripheral mass of protoplasm. Development begins with the fragmentation of the zygote nucleus, and at the end of the embryonic development the adult does not always hatch from the egg, but various types of larvae do which feed and undergo metamorphosis before the sexually mature adult emerges. In some cases, the larvae are in a fairly advanced state of development when hatched and often also possess the rudiments of wings. The metamorphosis in such cases is slight and the insects are classified as Heterometabola. In other cases, the larvae are in a very immature condition on hatching ; there is then an apparently quiescent pupal stage before the winged adult appears. There is thus complete metamorphosis in such insects and they are termed Holometabola.

Each change of form in the course of metamorphosis is marked by a moulting and usually also by an increase in size, weight and complexity of structure. An idea of the growth in size of insects may be gained from the fact that in some the sexually mature adult often weighs 70,000 times the newly hatched larva. During metamorphosis most larval structures undergo histolysis, in the course of which the tissues are broken down, often by phagocytosis, and the material thus obtained is utilized by masses of histoblasts in rebuilding the adult organs. Hormones and many external factors, chiefly temperature, regulate the course of insect metamorphosis.

*Classification*

Insects are classified on the basis of metamorphosis, wings, mouth parts and other characters. Table 1 gives an idea of the classification of the class *Insecta*.

*Distribution of Indian Insects*

With its wide range of geographical, climatic and other ecological conditions, India is exceedingly rich in insect life. There are reasons to believe that not less than half a million species of insects actually exist in India. However, a large number of insects is still unknown and only about 50,000 species occurring within the faunal limits of India (India proper, Pakistan, Burma, Ceylon, Nepal, Sikkim and Bhutan) have been described.

Of the 34 living orders of insects, only *Protura* and *Diploglossata* have not been recorded in India. The approximate numbers of species in various orders described so far from India are given in Table 2. *Coleoptera* and *Diptera* are the orders which approximately dominate the insect population in India. Although the order *Diptera* is only half as abundant as *Coleoptera*, there are reasons to believe that the number of species of this order actually occurring in India is not less than three or four times that of *Coleoptera*.

Though the great bulk of insects from India consists of oriental forms, especially the Indo-Malayan types, a certain proportion of Palaearctic and Ethiopean faunal elements are frequently met with in different parts of the country.

The Palaearctic faunal element is largely confined to the Himalayas, parts of the Punjab, Kashmir and neighbouring areas. The European component of the Palaearctic is, however, extremely small. Both Northern (Boreal) and Southern (Mediterranean) Palaearctic forms are found. The Ethiopean forms, as may be expected, are relatively more frequent in the desert areas, though some of the species occur

**TABLE 1—CLASSIFICATION OF CLASS INSECTA**

Class: *INSECTA* (*Hexapoda*)

Legion: *Pterygota* (winged insects)

Subclass I: *Exopterygota* (Heterometabola—Insects with simple metamorphosis)

Superorder i: Ephemeroidea
- Order 1: *Ephemerida*—Mayflies

Superorder ii: Perloidea
- Order 2: *Plecoptera*—Stoneflies

Superorder iii: Libelluloidea
- Order 3: *Odonata*—Dragonflies

Superorder iv: Embioidea
- Order 4: *Embioptera*—Embiids

Superorder v: Orthopteroidea
- Order 5: *Grylloblattoidea*—Grylloblatta
- Order 6: *Orthoptera*—Grasshoppers, locusts, crickets
- Order 7: *Phasmida*—Leaf insects, stick-insects
- Order 8: *Dermaptera*—Earwigs
- Order 9: *Diploglossata*—Hemimerids

Superorder vi: Blattoidea
- Order 10: *Blattaria*—Cockroaches
- Order 11: *Mantodea*—Praying mantids
- Order 12: *Isoptera*—Termites or white ants
- Order 13: *Zoraptera*—Zorapterans

Superorder vii: Psocoidea
- Order 14: *Corrodentia*—Book lice, psocids
- Order 15: *Mallophaga*—Bird lice, biting lice
- Order 16: *Anoplura*—True lice, sucking lice

Superorder viii: Thysanopteroidea
- Order 17: *Thysanoptera*—Thrips

Superorder ix: Hemipteroidea
- Order 18: *Heteroptera*—True bugs
- Order 19: *Homoptera*—Cicadas, aphids, mealy bugs, scale insects

Subclass II: *Endopterygota* (Holometabola—Insects with complete metamorphosis)

Superorder x: Coleopteroidea
- Order 20: *Coleoptera*—Beetles
- Order 21: *Strepsiptera*—Stylops

Superorder xi: Hymenopteroidea
- Order 22: *Hymenoptera*—Ants, bees, wasps

Superorder xii: Neuropteroidea
- Order 23: *Megaloptera*—Dobsonflies
- Order 24: *Neuroptera*—Lacewings
- Order 25: *Rhaphidoidea*—Snakeflies

Superorder xiii: Panorpoidea
- Order 26: *Mecoptera*—Scorpionflies
- Order 27: *Trichoptera*—Caddisflies
- Order 28: *Lepidoptera*—Butterflies, moths
- Order 29: *Diptera*—Flies, gnats, midges, mosquitoes
- Order 30: *Siphonaptera*—Fleas

Legion: *Apterygota* (primarily wingless insects)

Subclass III: *Thysanura*
- Order 31: *Thysanura*—Silverfish
- Order 32: *Aptera*—Japygids, campodeans

Subclass IV: *Collembola*
- Order 33: *Collembola*—Springtails, snowfleas

Subclass V: *Protura*
- Order 34: *Protura*—Proturans

TABLE 2—TAXONOMIC COMPOSITION OF INDIAN INSECT FAUNA

| Order | No. of species | % of total recorded |
|---|---|---|
| *Odonata* | 700 | 1.4 |
| *Orthoptera* | 330 | 0.7 |
| *Isoptera* | 175 | 0.4 |
| *Heteroptera* | 1,000 | 2.0 |
| *Homoptera* | 1,000 | 2.0 |
| *Coleoptera* | 20,000 | 40.0 |
| *Hymenoptera* | 5,000 | 10.0 |
| *Lepidoptera* | 7,000 | 14.0 |
| *Diptera* | 10,000 | 20.0 |
| Other Orders | 4,795 | 9.5 |
| Total | 50,000 | 100 |

as far south as Madras and as far east as Assam. Not all the species now found in India are really indigenous; several species have been introduced, unwittingly or deliberately, by man from various parts of the world, even from places as distant as Australia and South America. Nearly all these species have become naturalised and have often spread over vast areas of land, replacing some of the indigenous species. The common household cockroach, *Periplaneta americana* Linn., may be mentioned as an example of an insect brought by trading ships from tropical America. This species is at present found in every part of India and it is hard to realize that three or four centuries ago it was wholly unknown in the Old World. Another undesirable introduction in the early part of the present century is the notorious fluted scale (cottony cushion scale), *Pericerya purchasi* (Mask.), a native of Australia. The introduction of several species of Australian wattles as ornamental and avenue trees in South India brought the fluted scale also into the country, but its entry was not suspected until some years ago, when it had spread far and wide and threatened wattle cultivation. Notable among the deliberate introduction of foreign insects is the cochineal bug, a native of tropical South America, for the eradication of prickly pear in South India.

The distribution of insects in India is very uneven with respect to both species and numbers. India can be divided into eight subdivisions:

(1) The N. W. Himalayan and W. Tibetan subdivision includes the western parts of Tibet, Kashmir, Ladakh and the Himalayas west of the river Sutlej. This area is largely unexplored and the species recorded from it are about 6% of the total number of species described from India. The species are adapted for a cold, dry, wind-swept and mostly treeless area, and are generally endogenous or tericolous. True forest types are rare or wholly absent. In general the forms are of the Northern Palaearctic type.

(2) The E. Tibetan subdivision embraces the upper Brahmaputra valley within the Himalayas, North-East Frontier Agency, the eastern parts of Tibet and parts of Assam. These areas are relatively less dry. There is a conglomeration of south Palaearctic and north Indo-Malayan insect types and a pronounced preponderance of forest species.

(3) The C. and E. Himalayan subdivision covers Tehri-Garhwal, Kumaon, Nepal, Sikkim, Bhutan and the eastern end of the Himalayas. A large proportion of characteristic boreal Palaearctic species and typical Indo-Malayan forms are reported from this subdivision. The insect fauna is comparatively better known and the number of species so far described amounts to about 15% of the total number known from India.

(4) The Desert Zone comprises parts of the Punjab, Rajasthan, Gujerat and western parts of Uttar Pradesh. Although the dominance of Indo-Malayan types is evident, the Ethiopian and south Palaearctic (Mediterranean) insects are also abundant. Many species extend as far east as Kanpur in the Gangetic plain, whereas some typical forms of the Gangetic plain also occur near Ajmer in Rajasthan.

(5) The Gangetic Plain subdivision includes Uttar Pradesh, Bihar and Bengal and its insect fauna presents many striking features. True forest forms are sparse, but the grassland species appear to have changed into farm insects. The number of species recorded from the Gangetic plain is considerable and the area is more fully explored than most other parts of India. The bulk of the species consists of tropical types, many of which have become secondarily adapted to the winter of North India as evidenced by their brief hibernation. The insect fauna of this area appears to be relatively of recent origin and younger than that of Peninsular India.

(6) The W. Ghats faunal subdivision covers the narrow west coast plains, the Satpura, the Vindhyas, parts of the Deccan plateau and parts of the Aravallies. The forms are typically tropical rain forest types, and represent probably the oldest insect fauna of India. There is a pronounced affinity between

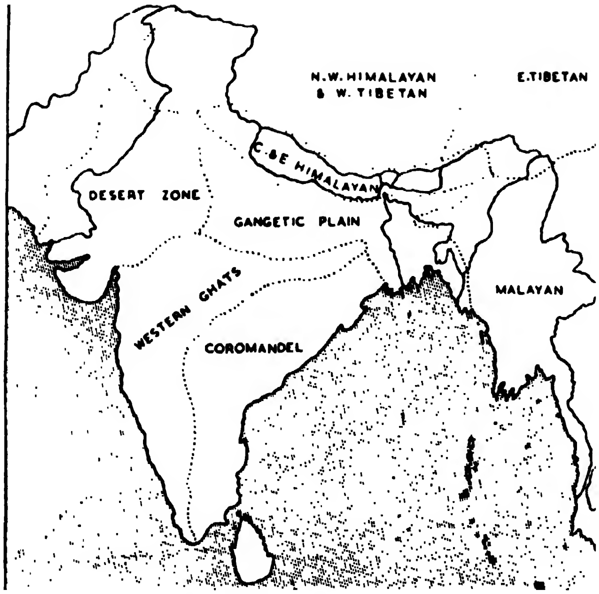



FIG. 115. MAP OF INDIA SHOWING FAUNAL SUBDIVISIONS WITH REFERENCE TO DISTRIBUTION OF INSECTS

the species of this subdivision and those of the subdivision comprising hilly areas of Burma and Assam. The insect species on the Vindhyas and Satpura show a transitional insect type between the Assam-Burma insect fauna and the western ghats fauna.

(7) The Malayan subdivision comprising in India the hilly areas of Assam is remarkable for the dominance of humid tropical genera and species which extend eastward to Thailand (Siam) and Philippines. Insect life of this subdivision is definitely older than that of the Gangetic plain and its origin may be contemporaneous with that of the western ghats.

(8) The Coromandel coast insect fauna is relatively better known than even that of the Gangetic plain, though parts of the eastern ghats have not been fully explored. The species found are mostly tropical plain forms, which seem to have been derived partly from the fauna of the western ghats and partly from the Vindhyan regions.

These faunal subdivisions differ widely in area, topography, climate, vegetation and other conditions and also exhibit more or less pronounced differences not only in the species of insects inhabiting them, but also in the habits, abundance and adaptations of the insects. Finally it has to be noted that the boundaries of these subdivisions are arbitrary.

From the standpoint of human economy, insects may be broadly classified into injurious, beneficial and neutral forms.

Insects which infest crops in the field and agricultural produce during storage and those which cause diseases in man and farm animals are directly injurious; those which attack other insects which are beneficial to man are indirectly injurious. Insects which serve as pollinators of plants, destroyers of noxious weeds and as natural scavengers may be grouped under beneficial insects; predators and parasites of insects which attack crops are indirectly beneficial. Some forms are used as food for fish and other animals, even man; some insects possess medicinal properties and some yield useful products, like dyes, lac, silk, honey and wax. The majority of insects are economically unimportant.

## Injurious Insects and Their Control

The major insect pests of cultivated and forest plants are briefly mentioned in the following paragraphs; more detailed accounts are found under individual plants.

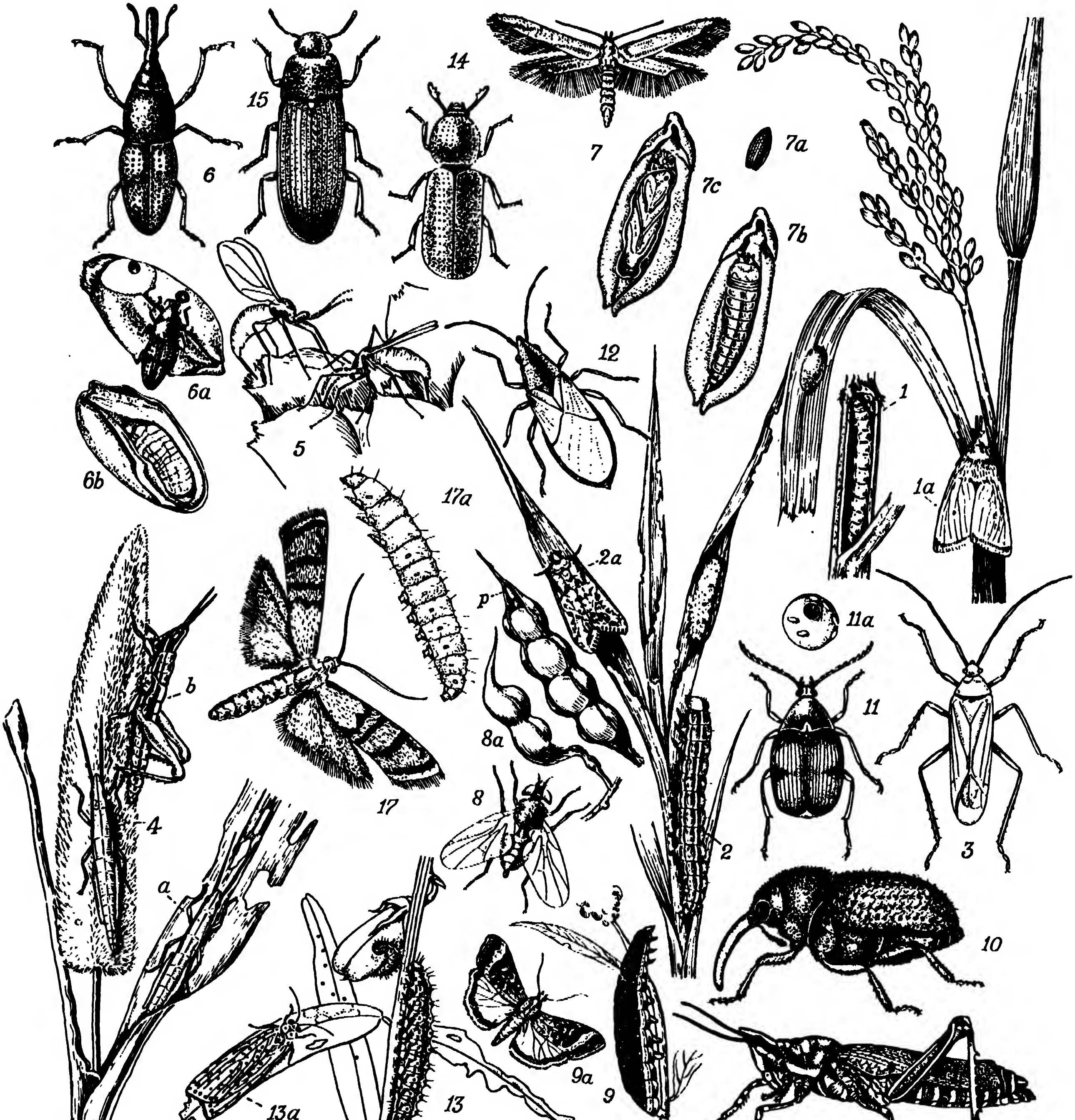
### PESTS OF CULTIVATED PLANTS

*Cereal Crops*

The rice crop in India is subject to the attacks of several serious pests. Seedlings in nurseries are subject to the depredations of the swarming caterpillar, *Spodoptera mauritia* Boisd., and the leaf beetles, rice hispa, *Hispa armigera* (Oliv.), and blue beetle of paddy, *Leptispa pygmaea* Baly. At the tillering stage the crop is subject to the silver-shoot disease (Tam.–*Anaikombu*; Tel.–*Kodu*) caused by the gallfly, *Pachydiplosis oryzae* (W. M.) Mani: it is also attacked by the rice grasshopper, *Hieroglyphus banian* Fabr., and the phadka or kharif grasshopper, *H. nigrorepletus* Bol. The rice mealy bug, *Ripersia oryzae* Gr., causes the *soorai* disease of paddy. Various leaf bugs and the caseworm, *Nymphula depunctalis* Guen., cause damage to young paddy. Earheads are attacked by the rice bug, *Leptocorisa varicornis* Fabr. The stem borer, *Schoenobius incertellus* Wlk., and the root-weevil, *Echinocnemus oryzae* Mshll., are also serious pests. For the control of the pests, spraying or dusting with DDT or BHC is effective. The larvae and grubs of caseworms and beetles are destroyed by flooding the field and adding a little kerosene oil: tobacco refuse or a mixture of superphosphate and ammonium sulphate is applied as manure. A few wasps and parasitic flies attack the caterpillars.

The wheat crop in India is comparatively free from serious insect pests. In Peninsular India, wheat

Pl. VIII




PESTS OF CULTIVATED PLANTS AND STORED AGRICULTURAL PRODUCTS

**1. Paddy stem-borer** (*Schoenobius incertellus*) **inside the stem of rice plant** (×1½); **1a. female moth** (×1½) **2. Swarming caterpillar** (*Spodoptera mauritia*) **on rice plant (nat. size); 2a. moth (nat. size) 3. Green earhead bug** (*Calocoris angustatus*), **female** (×4) **4. Deccan grasshopper** (*Colemania sphenarioides*) **feeding on millet crop** (×3/5); **a. dorsal view; b. side view 5. Jowar gallflies** (*Contarinia andropogonis*) **in the act of oviposition on earhead of jowar** (×7) **6. Rice weevil** (*Sitophilus oryzae*) (×8); **6a. weevil gnawing into a wheat grain; 6b. larva inside a wheat grain 7. Angoumois grain moth** (*Sitotroga cerealella*) (×3); **7a. egg; 7b. larva; 7c. pupa inside a grain 8. Tur pod fly** (*Agromyza obtusa*) (×6); **8a. affected pods showing puparium at 'p' 9. Lucerne caterpillar** (*Laphygma exigua*) **(nat. size); 9a. moth (nat. size) 10. Red gram bud weevil** (*Ceuthorrhynchus asperulus*) (×10) **11. Pulse beetle** (*Bruchus chinensis*) (×7); **11a. affected pea showing eggs and exit hole of the beetle 12. Dusky cotton bug** (*Oxycarenus laetus*) (×6) **13. Caterpillars of sann hemp moth** (*Utetheisa pulchella*) **feeding on leaves and pods of sann hemp (nat. size); 13a. moth (nat. size) 14. Lesser grain borer** (*Rhizopertha dominica*) (×10) **15. Rustred flour beetle** (*Tribolium castaneum*) (×9) **16. Aak grasshopper** (*Poecilocerus pictus*) (×¾) **17. Indian meal moth** (*Plodia interpunctella*) (×3); **17a. larva** (×3)

is subject to light attacks by white ants like *Microtermes obesi* Holmg., the stem-borer, *Sesamia inferens* (Wlk.), and the plant louse, *Toxoptera graminum* Rond.; the wheat aphid, *Macrosiphum avenae* Fabr., the gujhia weevil, *Tanymecus indicus* Fst., the armyworm, *Cirphis unipuncta* Haw., and termites are pests in North India. In the hilly areas of Kulu and Kangra (E. Punjab) the earhead bug, *Eurygaster maura* Linn., is a serious pest. Dusting with BHC may control most of these pests. Spraying with Diazinon or nicotine sulphate will control plant lice or aphids.

Young millet crops are subject to the depredations of the red hairy caterpillar, *Amsacta albistriga* Wlk. (Tam. *Kamblipuchi*; Tel. *Gongalipurugu*), in South India and Deccan and of *A. moorei* Butl. in North India. These are whitish moths with a few black spots on the wings, which emerge in large numbers with the fall of the first monsoon rain in June. The pest can be controlled either by hand picking of the moths or trapping them by light; marching bands of young caterpillars may be controlled by spraying or dusting with BHC. The stem-boring maggots of *Atherigona* spp. attack young plants of various millets. In the case of jowar (*Sorghum vulgare* Pers.), *A. indica* Mall. bores into the stem of the young plant and causes the shoot to wither and dry up. The spiked millet or bajra (*Pennisetum typhoides* Stapf & Hubbard) is affected by *A. approximata* Mall.; the Italian millet (*Setaria italica* Beauv.) by *A. atripalpis* Mall.; ragi (*Eleusine corocana* Gaertn.) by *A. milliaceae* Mall.; the small millet (*Panicum miliaceum* Linn.) by *A. destructor* Mall.; and *Paspalum scrobiculatum* Linn. by *A. bituberculatum* Mall. Usually they are not serious pests, though damages up to 30 and even 50% have sometimes been reported.

At the tillering stage, various grasshoppers have been known to attack millets; for instance, the Deccan grasshopper, *Colemania sphenarioides* Bol. (Tel.—*Midatha*; Kan.—*Jitti*), is common in many parts of Deccan from Ahmednagar in the north, to Shimoga, Chitaldrug, Bellary and Kurnool in the south; the phadka grasshopper, *Hieroglyphus nigrorepletus* Bol., infests jowar, maize and other cereal crops in Ajmer, southern Punjab, U.P. and M.P. in the north and some districts of Andhra Pradesh in the south; the adults and their nymphs feed on leaves and ultimately attack the earhead. Dusting with BHC has proved effective as a control measure.

Growing crops are subject to the attacks of plant lice and shoot bugs. Many millets are affected by *Rhopalosiphum* (*Aphis*) *maidis* Fitch, though usually the damage is not serious. Predatory insects, like ladybird beetles, chrysopids and hoverfly maggots, keep the pest in check. Jowar and maize are subject to the attack of the shoot bug, *Dicranotropis* (*Peregrinus*) *maidis* Ashm., which infests the inside of the top-whorls of plants. Eggs are laid in midribs and the bugs feed on top leaves; the whorls become filled with honeydew and the leaves rot and dry up. The green earhead bug or fire insect, *Calocoris angustatus* Leth. (Tam. *Navaipuchi*; Tel. *Aggipurugu*), often attacks jowar in the earhead stage; eggs are laid inside the stem and the bugs, after hatching, suck the sap. Dusting with BHC has proved effective as a control measure. Gall midges lay eggs in florets and cause them to dry up. Jowar gallfly, *Contarinia andropogonis* Felt, attacks jowar and *Itonida seminis* Felt is known to infest spiked millet (bajra) causing numerous blanks in the setting of grains. Dusting with BHC is effective in controlling the pest.

Maturing earheads are often subject to attack by various caterpillars. Maize cobs are often damaged by the gram caterpillar, *Heliothis armigera* Hübn.; earheads of jowar, especially in the compact-head variety, are webbed up as a result of infestation by *Stenachroia elongella* Hmpsn. and grains are partially eaten up. Some of the stored grain pests, e.g. rice weevil, *Sitophilus* (*Calandra*) *oryzae* Linn., and Angoumois grain moth, *Sitotroga cerealella* Oliv., frequently attack developing ears and lay eggs on grains.

Stems and roots are liable to attack by stem-boring caterpillars. The jowar stem borer, *Chilo zonellus* (Swinh.), is often a serious pest especially on rain-fed crops. It is also a pest of bajra, ragi and sugarcane. The pink borer, *Sesamia inferens* (Wlk.), attacks shoots of maize, wheat, ragi and sugarcane. The white borer, *Saluria inficita* (Wlk.), attacks ragi (*Eleusine coracana* Gaertn.) in South India. The kangni crop of the Italian millet (*Setaria italica* Beauv.) is sometimes damaged by the grubs of an erotylid beetle, *Anadastus parvulus* Wied., which bores into the stem and ultimately rings up the joint from inside, the tunnel causing the plant to dry up. This species has so far been noted only in south Madras. In some sub-montane areas of India, cockchafer grubs are known to attack roots and cause large patches of the jowar crop to wilt and dry up. Some of the millets in South India are subject to damage by root aphids, chiefly *Tetraneura hirsuta* Bak. The pest is controlled by irrigating the field with water containing crude oil emulsion, fish oil, soap or tar.

*Pulse and Legume Crops*

In the early stages of growth, the summer crops, such as red gram (*Cajanus* spp.), green gram (*Phaseolus aureus* Linn.) and cowpea (*Vigna* spp.), which are usually sown at the commencement of the monsoon, are subject to depredations by the red hairy caterpillars, *Amsacta* spp., while winter crops, like gram (*Cicer* spp.) and peas (*Pisum* spp.) and lentils (*Lentis* spp.), which are sown in autumn, are liable to cutworm attack in North India. Young plants of cowpea, beans and peas are attacked by the stem-fly, *Melanagromyza phaseoli* Coq., which causes the plants to wilt and dry up. Peas are liable to damage by the leaf-mining maggot, *Phytomyza atricornis* Meign.

The foliage of legume crops is often denuded by various caterpillars; green gram and beans are affected by large sphingids as well as by hairy caterpillars like *Diacrisia obliqua* Wlk.; peas and lentils are subject to attack by certain caterpillars, such as lucerne caterpillar (*Laphygma exigua* Hübn.) and *Prodenia litura* Fabr. The leaves of young gram plants are eaten by caterpillars of *Heliothis armigera* Hübn. which later bore into pods and cause wholesale damage to the crop. Dusting with BHC or spraying with DDT or Endrin may be effective.

During the flowering stage, red gram is subject to damage by a number of insect pests; flower buds are affected by the red gram bud weevil, *Ceuthorrhynchus asperulus* Fst., and young pods are damaged by various caterpillars; the tur pod maggot, *Agromyza obtusa* Meign., damages seeds. A weevil grub, *Pachytychius mungonis* Mshll., bores into developing green gram seeds. Pods of field bean (*Dolichos lablab* Linn.) in Peninsular India are subject to attack by the caterpillar borer, *Adisura atkinsoni* Moore. The seeds of many leguminous crops are liable to attack by bruchid or pulse beetles during storage: individual species often restrict their attention to particular species of pulses and the attack in many cases starts in the field before harvesting. Red gram is attacked by *Bruchus theobromae* Linn. which lays eggs on the pods, but does not breed on stored grain; on the other hand, *B. chinensis* Linn. infests pods in the field and also breeds under storage. Field bean is subject to attack by *B. phaseoli* Gyll. which breeds also on stored seeds; *Callosobruchus maculatus* Fabr. infests cowpeas. Peas are infested in the field by both *Bruchus chinensis* Linn. and *B. affinis* Frol.; the latter does not breed under storage. These pests in storage are controlled by fumigation with a mixture of ethylene dichloride and carbon tetrachloride or with methyl bromide. Seeds for sowing can be preserved by treating them with DDT or BHC before storage.

*Oilseed Crops*

Most of the oilseed crops are attacked by the red hairy caterpillar when young. Til (*Sesamum indicum* Linn.) is subject to serious damage by the til leaf and pod caterpillar, *Antigastra catalaunalis* Dup., which webs shoots and feeds on flowers and young capsules. The til sphinx caterpillar, *Acherontia styx* Westw., feeds on leaves. Flowers may be turned into galls by a gall midge, *Asphondylia sesami* Felt. Protection in the case of mild attacks is afforded by removing and destroying affected leaves, shoots, galls and buds. Spraying with insecticides is neither effective nor economical in the case of the gall midge. Heavy infestations of til and sphinx caterpillars may be economically controlled by dusting the crop with BHC or spraying with DDT.

Groundnut (*Arachis hypogaea* Linn.) is subject to damage by several pests. A leaf-mining caterpillar, *Stomopteryx nerteria* Meyr. (Tam. *Surul puchi*), often causes serious damage. The red hairy caterpillar, *Amsacta albistriga* Wlk., is in many places a menace to young crop. The root-borer, *Sphenoptera perrotetti* Guen. (Tam. — *Verpuchi*), infests the root and plants in full bearing causing them to wilt and dry up. Light traps have proved useful in the early stages to attract the moths; beetles affecting roots may be hand picked and destroyed.

Castor (*Ricinus communis* Linn.) is subject to attack by numerous pests, mainly caterpillars, including hairy species (*Amsacta* spp., *Pericallia ricini* Fabr., *Euproctis fraterna* Moore), nettlegrub (*Parasa lepida* Cram.), castor butterfly (*Ergolis merione* Cram.) and tobacco worm (*Prodenia litura* Fabr.). The chief enemy of castor crop is, however, the castor semi-looper, *Achaea janata* Linn., which may entirely defoliate whole areas within a few days. Severe damage is also caused by the capsule borer, *Dichocrocis punctiferalis* Guen., which webs capsules and devours tender seeds. Leaves are attacked by the leaf hopper, *Empoasca flavescens* Fabr., and the castor whitefly, *Trialeurodes ricini* Mask. Collection of egg masses and larvae and their destruction along with leaves on which the caterpillars feed gregariously are effective as control measures in small areas, and dusting or spraying with DDT or BHC in larger areas.

Both safflower (*Carthamus tinctorius* Linn.) and nigerseed (*Guizotia abyssinica* Cass.) are liable to damage by the caterpillars of *Perigea capensis* Guer. Safflower is subject to infestation also by the plant louse, *Macrosiphum jaceae* (Linn.), and the tingid bug, *Monanthia globulifera* Wlk. Flowerheads are often bored into by the fly maggot, *Acanthiophilus helianthi* Rossi, in Delhi, Uttar Pradesh and parts of the Punjab. Spraying with DDT against caterpillar pests and with Diazinon against plant lice and the tingid bug may prove effective.

Linseed is damaged in the younger stage by the caterpillars of *Grammodes* and *Laphygma* spp. In North India, the linseed gall-midge, *Dasyneura lini* Barnes, appears in the cold months and is responsible for 20-40% damage to the flowers of the plant.

Mustard (*Brassica* spp.) in the early stages of its growth is damaged by the grubs of the mustard sawfly, *Athalia proxima* Klug., and in the flowering stage by the mustard aphis, *Lipaphis erysimi* Davis. The population of the latter at times multiplies so enormously as to cause the total failure of mustard crop. Diazinon is effective against mustard aphis and dusting with BHC controls the sawfly.

*Fibre Crops*

Cotton plant in the seedling stage is liable to severe damage by the crickets, *Gryllus domesticus* Linn. and *Gryllus viator* Kirb., weevils, such as *Atactogaster finitimus* Fst., and the red hairy caterpillar, *Amsacta* spp. Growing plants are often attacked by various species of *Amsacta*, *Euproctis*, *Laphygma* and *Prodenia*, the cotton leaf roller, *Sylepta derogata* Fabr., and semi-loopers, such as *Anomis* spp., *Acontia* sp. and *Tarache nitidula* Fabr. Tender shoots may be bored into by the bud caterpillar, *Phycita infusella* Meyr., and the spotted bollworms, *Earias fabia* Stoll. and *E. insulana* Boisd. The plant is attacked by various sucking insects, such as the cotton aphis, *Aphis gossypii* Glov., the cotton jassid, *Empoasca devastans* Dist., the cotton whitefly, *Bemesia tabaci* Greenn. & Bak., and the mealy bug, *Ferrisiana virgata* (Ckll.). The most serious pests of cotton are the pink bollworm, *Platyedra gossypiella* Saund., and the spotted bollworm (*Earias* spp.). The bolls are also liable to attack by the red cotton bug, *Dysdercus cingulatus* Fabr., and the dusky cotton bug, *Oxycarenus laetus* Kirb. Cotton plants wilt and dry up by the attack of the stem borer, *Sphenoptera gossypii* Kirb. Galls may also be formed in the stem due to the attack of the stem weevil, *Pempheres affinis* Fst., causing either death or breakage at the place of attack. In some cases, the shoots may be galled by the shoot weevil, *Alcides mysticus* Faust. Spraying or dusting with BHC or DDT helps to keep down many of these pests.

In the case of the jute crop (*Corchorus* spp.), the length of the fibre is the main criterion of a good crop, and any pest stunting plant growth or breaking the fibre is considered serious. In the early stages, the jute plant is subject to attack by swarming caterpillars, like *Laphygma exigua* Hübn. and *Diacrisia obliqua* Wlk., and the jute semi-looper, *Anomis sabulifera* Guen., which keep down the growth of the crop. The leaf-mining beetle, *Trachys pacifica* Kerr, and the yellow mite, *Hemitarsonemus laetus* Banks, tend to weaken the plant. Another serious pest is the jute weevil, *Apion corchori* Mshll., which lays eggs in the top-shoot of young plants, in which case side shoots are produced, or in the axils of leaves of grown up plants, when the fibres are cut up by grubs. The cricket, *Brachytrypes portentosus* Licht., is, at times, a serious pest of jute crop. Spraying or dusting with DDT or BHC helps to keep down several of these pests. Lime-sulphur spraying controls mites.

In the early stages, sann hemp is damaged by the flea beetle, *Longitarsus belgaumensis* Jacoby, and grasshoppers. The growing crop is liable to attack by caterpillars of sann hemp moths, *Utetheisa pulchella* Linn., *Argina cribraria* Clerck and *A. syringa* Cram.; top shoots are bored into by the gall-producing moth, *Enarmonia pseudonectis* Meyr. At times, the whole crop is ruined by the infestation of the capsid bug, *Ragmus importunitas* Dist. Deccan hemp (*Hibiscus cannabinus* Linn.) is damaged by caterpillars in the young stage and by shoot-boring weevils, *Alcidodes leopardus* Oliv. and *A. affaber* Fst., later. Collection of moths by hand picking and netting is helpful in checking the pests. Light traps and sticky boards are also used for trapping. Spraying or dusting with DDT may prove beneficial in serious infestations.

Central shoots of the agave plant (*Agave americana* Linn.) are subject to attack, at the base, by the rhinoceros beetle, *Oryctes rhinoceros* Linn.

*Cash and Plantation Crops*

The chief insect pests of sugarcane are the termites, moth borers, leaf-hoppers, mealy bugs and mealy wings; of these, the borers and leaf hoppers cause serious damage.

Sugarcane setts are liable to attack by white ants, chiefly *Odontotermes* (*Cyclotermes*) *obesus* Ramb.,

after planting. Dusting of cane furrows with Aldrin or BHC before planting of setts provides control.

The moth borers, *Argyria sticticraspis* Hmpsn. and *Diatroea venosata* Wlk., are typical stem borers ; the top shoot or white borer, *Scirpophaga nivella* Fabr., bores into the top shoot. In the Punjab, the Punjab borer, *Bissetia steniella* (Hmpsn.), appears late in the season, but often ruins the cane. The rootstock borer, *Emmalocera depressella* (Swinh.), attacks tillers and rootstock, and sometimes causes great damage. The crop can be protected by planting borer-free setts and removing any attacked plants and destroying egg masses. Earthing up of young crop followed by irrigation helps to reduce the damage. Biological control with the help of the egg parasite, *Trichogramma minutum* Riley, was tried in some parts of India but without much success.

Sugarcane is subject to the attack of several sap-sucking bugs, which in aggregate cause a fair amount of damage. The sugarcane leaf-hopper, *Pyrilla perpusilla* Wlk., often multiplies in large numbers and causes stunting and yellowing of crops. The cane whitefly, *Aleurolobus barodensis* Mask., attacks the lower surface of leaves and is often a serious pest. Various species of mealy bugs also attack sugarcane, the most common being *Saccharicoccus sacchari* Ckll. which attacks the joints under the cover of leaf sheaths. In parts of the Punjab, the black bug, *Macropes excavatus* Dist., causes serious damage to sugarcane.

In certain parts of India, sugarcane is liable to heavy damage by the rice and kharif grasshoppers, *Hieroglyphus banian* Fabr. and *H. nigrorepletus* Bol., during July October. These pests can be checked by dusting the crop with BHC.

Tobacco (*Nicotiana tabacum* Linn.) and other narcotics are also attacked by insects. In the nursery stage as well as in the early stages of growth of tobacco in the field, the tobacco caterpillar, *Prodenia litura* Fabr., often appears in destructive numbers : the cutworm, *Agrotis ypsilon* Rott., as well as crickets and grasshoppers attack the crop in North India. As the quality and market value depend on the flawlessness of tobacco leaves, freedom from pests is a matter of utmost concern to the grower. Infestations of the aphid, *Myzus persicae* (Sulz.), cotton whitefly, *Bemesia tabaci* Greenn. & Bak., and tobacco bug, *Engytatus tenuis* Rütt., cause leaf-curl. The gram caterpillar, *Heliothis armigera* Hübn., attacks the capsules of seed plants. This pest also attacks the heads of opium poppy and the top shoots and inflorescence of cultivated ganja (*Cannabis sativa* Linn.). The most serious pest of ganja is, however, the mite, *Tetranychus telarius* (Linn.). The poppy seedlings in early stages are at times destroyed by the gujhia weevil, *Tanymecus indicus* Fst., in North India. In most cases the caterpillar and weevil pests are controlled by dusting with BHC or DDT and aphid and mite pests by Diazinon and lime-sulphur sprays respectively.

Pepper (*Piper nigrum* Linn.), which is grown as a perennial plantation crop in the moist west coast of Peninsular India, is subject to infestation by scales and mealy bugs. The most serious pest is, however, the pepper flea beetle or pollu beetle, *Longitarsus nigripennis* Motsch., which lays eggs in berries ; the grubs after hatching hollow out the berries. Full-grown grubs drop to the ground and pupate in the soil. As a precautionary measure, the soil should be hoed around the vines to destroy the pupae of the beetle. Muscle scale of pepper, *Mytilaspis piperis* Gr., and the pepper mealy bug, *Pseudococcus virgatus* Ckll., which are serious pests in South India, are controlled by spraying with fish oil rosin soap and Malathion respectively.

Betel vine (*Piper betle* Linn.) is sometimes affected by the mealy bug, *Ferrisiana virgata* (Ckll.), but the major pest of betel is the mosquito bug, *Disphinctus politus* Wlk. ; *D. maesarum* Kirk. is more common in the Bombay area. The adult bug punctures tender leaves and lays eggs on the vine ; the tiny bugs that hatch out similarly puncture young leaves. Netting and trapping of adults and nymphs with sticky winnows and cones, and spraying with repellent mixtures are recommended as control measures. Dusting with pyrethrum powder also controls the bug.

The chief pest of indigo (*Indigofera arrecta* Hochst.) is indigo psylla, *Arytaina punctipennis* Crawf., which attacks top shoots and causes stunting of the crop.

Turmeric (*Curcuma longa* Linn.), arrowroot (*C. angustifolia* Roxb.) and ginger (*Zingiber officinale* Rosc.) are subject to attacks by leaf caterpillars, thrips, *Panchaetothrips indicus* Bagn., and a tingid bug, *Stephanitis typicus* Dist. The caterpillar of *Dichocrosis punctiferalis* Guen. bores into the shoots of turmeric and ginger and destroys the crops. The caterpillar of turmeric skipper, *Udaspes folus* Cram., is also a serious pest of these crops. Cumin and coriander are subject to attack by a caterpillar, *Laphygma exigua* Hübn., and two sucking insects, viz. a flower-head bug and an aphid.

Cardamom (*Elettaria cardamomum* Maton) is subject to attack by several pests. The caterpillars of *Eupterote canaraica* Moore appear in enormous numbers in some years on trees in the forest areas in which cardamom is cultivated ; after defoliating the trees, the caterpillars descend by silk threads on to the lower vegetation, including the cardamom crop, which may be severely attacked. *Taeniothrips cardamomi* Ayyar, the cardamom thrips, is a serious pest of cardamom ; it punctures flowers and tender fruits and thereby ruins the crop. A root weevil, *Prodioctes haematicus* Chevr., attacks the rhizomes and pseudostems by boring into them, and is considered to be responsible for the increase of the clump-rot disease in Kerala.

A psyllid bug, *Paurosylla depressa* Crawf., has been recorded in different parts of the western ghats on *Cinnamomum zeylanicum* Breyn. Nymphs and adults of the pest cause galls on leaves and shoots of the plant.

A few species of the soft scale, *Lecanium* spp., have been noted in certain hilly areas on trees of camphor, nutmeg and cloves.

The pods of cacao (*Theobroma cacao* Linn.) are infested by a mealy bug, *Pseudococcus citri* Risso. Cacao thrips, *Selenothrips rubrocinctus* Giard, is a serious pest in plantations.

The foliage of coffee is subject to the attacks of various caterpillars, beetles and sap-sucking insects, but the most serious pest is the green bug, *Coccus viridis* Gr., which was one of the causes of the disappearance of coffee as a main crop from Ceylon. The stem borer of coffee, *Xylotrechus quadripes* Chevr., is a serious pest of coffee in South India. The shot-hole borer, *Xyleborus morstatti* Haged., is sometimes a serious pest.

Tea crops are seriously affected by the tea mosquito, *Helopeltis theivora* Waterh., in North India and by *H. antonii* Sign. in South India ; the pests attack tender flushes. The adults as well as young bugs puncture the shoots and cause them to wilt. The red spider or tea red mite, *Tetranychus bioculatus* W.M., also attacks new flushes of leaves. The termite, *Coptotermes* sp., establishes nests in the heartwood of live bushes. The plant is also subject to attacks by scale insects, leaf-hoppers, plant-lice, thrips and mites. The foliage may be devoured by several species of caterpillars, e.g. the red slug, *Heterusia cingala* Moore, the looper, *Buzura* sp., nettle or gelatine grubs, *Thosea*, *Parasa* and *Belippa* spp., bagworms, the sandwich caterpillar, *Synchalara* sp., the crab caterpillar, *Staurepus* sp., and the bunch caterpillar, *Andraca* sp. Among the pests attacking stems and twigs, the shot-hole borer, *Xyleborus fornicatus* Eich., is a serious pest in Ceylon and in some parts of South India.

*Cinchona ledgeriana* Moens is liable to defoliation by the cockchafer beetles, *Holotrichia repetita* Shp. and *Rhizotrogus rufus* Arrow, at the commencement of the rains. Tender shoots are often damaged by the tea mosquitoes, *Helopeltis* spp. and *Disphinctus humeralis* Wlk. Destruction of underground grubs and irrigation of seed beds with crude oil emulsion mixed with water check the pests.

The bark of the rubber tree (*Hevea brasiliensis* Muell.-Arg.) is sometimes attacked by bark eating caterpillars, *Comocritis* spp. and *Aetherastis* spp., in Ceylon and Kerala. Stems may be bored into by grubs of *Batocera rubus* Linn. and trees are sometimes attacked by the termite, *Glyptotermes dilatatus* Havil., which builds nests in the heartwood. Certain scale insects, e.g. *Aspidiotus cyanophylli* Sign., *Saissetia* (*Lecanium*) *nigra* Nietn., are often found on twigs and foliage.

*Vegetable Crops*

The insect pests of brinjal (*Solanum melongena* Linn.) are chiefly borers, leaf eaters and, occasionally, a few sucking forms. The leaf eating ladybird beetle, *Epilachna 28-punctata* Fabr., is often destructive ; it attacks the crop both in the grub and adult stages. The beetle also attacks other vegetable crops, such as potato, tomato and various cucurbits. Certain species of lacewing bugs, e.g. *Urentius echinus* Dist., breed in numbers on young crops of brinjals ; older plants are often infested with colonies of a mealy bug, *Phenacoccus insolitus* Gr. The jassid, *Empoasca devastans* Dist., infests the foliage. The pink caterpillar, *Leucinodes orbonalis* Guen., bores first into top shoots and later into fruits and lowers the market value of crops. The borer *Euzophera perticella* Rag. bores the stem. Destruction of attacked shoots, fruits and buds, and adoption of cultural methods which stimulate vigorous growth are recommended for checking the pests. Attacked plants are dusted or sprayed with DDT or BHC for the control of the ladybird beetle and some of the sucking insects.

Among the pests of tomato (*Lycopersicon esculentum* Mill.) mention should be made of *Epilachna* spp. and the gram caterpillar, *Heliothis armigera* Hübn., which eats into fruits in the unripe stage.

Hand picking and application of stomach insecticides provide effective control.

A wide range of cultivated vegetable crops, such as cucumber, pumpkin and bitter gourd, belonging to the family *Cucurbitaceae* are subject to attack in the early stages of growth by the red pumpkin beetle, *Aulacophora foveicollis* Lucas. Not only are leaves eaten up, but roots are damaged by grubs of the beetle. Floral parts of some of these crops are destroyed by the banded blister beetle, *Mylabris pustulata* Thunb. Fruits are damaged by maggots of the fruitflies, *Dacus cucurbitae* (Coq.), *D. ciliatus* Loew. and *D. caudatus* Fabr. Leaves of creepers are often damaged by caterpillars of the snakegourd semilooper, *Plusia* (*Phytometra*) *peponis* Fabr. Various kinds of bugs (*Aspongopus* spp.) and plant lice (*Aphis* spp.) desap the leaves. Shoots of bitter gourd are subject to attack by the gallfly, *Lasioptera falcata* Felt, which causes galls to develop at distal shoots. The beetles of *Epilachna* spp. attack most curcurbits with the exception of bottle gourd, *Lagenaria siceraria* Standl., which is affected by the plume moth, *Sphenarches caffer* Zell. Dusting with BHC or DDT controls several of these pests. Fruitflies are controlled by destroying damaged fruits and trapping flies by poisoned syrups.

Lady's finger (*Hibiscus esculentus* Linn. ; Hindi—*Bhindi*) is subject to attack by many of the cotton pests, e.g. spotted bollworm, *Earias* spp., red cotton bug, *Dysdercus cingulatus* Fabr., shoot weevil, *Alcidodes affaber* Fst., and cotton jassid, *Empoasca devastans* Dist. Floral parts are damaged by banded blister beetles, *Mylabris phalerata* Pall and *M. pustulata* Thunb. Spraying with DDT controls the caterpillar and bug pests while hand netting may help in the control of banded beetles.

The drumstick tree (*Moringa oleifera* Lam.) is often infested by gregarious bands of the woolly caterpillar, *Eupterote mollifera* Wlk. : leaves and flower buds are liable to attack by caterpillars of *Noorda blitealis* Wlk. The woolly caterpillar may be destroyed by applying a lighted torch to the trunks.

The common pests of cabbage, cauliflower, turnips, radish and a few other members of the *Cruciferae*, which grow in temperate regions, are the sawfly, leaf eating and leaf boring caterpillars, cutworms and plant bugs, including plant lice and stink bugs. Insect pests of garden crops, like cabbage and radish, are more or less identical with those of field-grown cruciferous crops, such as mustard, sarson and rapeseed. The pests attacking the foliage are the mustard sawfly, *Athalia proxima* Klug., the larvae of which resemble caterpillars ; the diamond-back moth, *Plutella maculipennis* Curt. ; the cabbage webworm, *Hellula undalis* Fabr., and the cabbage butterfly, *Pieris brassicae* Linn., which is confined to the submontane areas of North India. Among the sap sucking insects, the cabbage or the painted bug, *Bagrada cruciferarum* Kirk., is often a serious pest and the mustard aphis, *Lipaphis erysimi* Davis, is sometimes destructive. The small flea beetle, *Phyllotreta cruciferae* Goez., and the onion thrips, *Thrips tabaci* Lind., sometimes infest young cabbage, cauliflower and radish plants. Caterpillar pests are hand picked and destroyed. Spraying or dusting with DDT or BHC destroys most of the pests.

Capsicum or chillies are subject to the leaf-curl disease, caused by the infestation of the thrips, *Scirtothrips dorsalis* Hood. As a remedial measure, nursery seedlings are dusted with tobacco powder before transplantation in the field. Spraying or dusting with BHC will also control them.

Among leafy vegetables, *Amaranthus* spp. are liable to attack by the stem boring weevil, *Hypolixus truncatulus* (Boh.), which produces gall-like thickenings. *Lamprosema* (*Nacoleia*) sp. also attacks plants in early stages. The top shoots of affected plants may be clipped and weevils hand picked and destroyed ; wild amaranthus plants growing nearby should be removed and destroyed since they serve as hosts for weevils during the off season.

Among the pests of sweet potato (*Ipomoea batatas* Lam.), mention should be made of the caterpillars of sphinx moth, *Herse convolvuli* Linn., tortoise beetle, *Aspidomorpha miliaris* Fabr., and *Metriona circumdata* Hbst. By far the most troublesome pest is the sweet potato weevil, *Cylas formicarius* Fabr., which infests tubers in the field and lays eggs in them ; the eggs develop in the tubers during storage. Deep planting of vines is recommended as a measure of checking infestation. Storage godowns must be fumigated from time to time.

Potato (*Solanum tuberosum* Linn.) is subject to infestation by a number of pests. Young plants are liable to attack by the cutworms, *Agrotis* spp. and *Euxoa* spp. : the growing crop is affected by epilachna beetles and the cotton jassid. The most serious pest is, however, the potato moth, *Gnorimoschema operculella* Zell., which is a leaf miner but causes most damage to tubers under storage. Infested potatoes should be destroyed. Sand storage of potatoes keeps off the pest ; infestation during transportation should be guarded against.

Onions and garlic are liable to damage in the field by the infestation of onion thrips, *Thrips tabaci* Lind. Banded groundnut thrips, *Heliothrips indicus* Bagn., infests onions occasionally, lacerates the foliage and sucks the sap. As a control measure, plants may be dusted with tobacco powder or sprayed with a decoction of tobacco. Periodical irrigation and harrowing of the field are effective in warding off the pest. Spraying or dusting with BHC is also effective.

The foliage of elephant yam (*Amorphophallus* spp.) is often attacked, though not seriously, by a red-and-black spotted beetle, *Galerucida bicolor* Hope. Stored tubers are often infested by the scale insect, *Aspidiotus hartii* Ckll. Tapioca plants (*Manihot esculenta* Crantz) are sometimes attacked by the scale insect, *Aonidomytilus albus* Ckll., in South India.

Very few insects infest *Colocasia*. The white-spotted flea beetle, *Monolepta signata* Oliv., eats the leaves. Dusting with arsenate powders is recommended as a control measure.

Koorkan (*Coleus parviflorus* Benth.), commonly grown as a tuber crop in the west coast, is subject to attack by two leaf eating pyralid caterpillars, *Pycnarmon cribrata* Fabr. and *Phostria piasusalis* Wlk. The former is checked by a braconid parasite, *Microgaster psarae* Wlksn. Bean crops are subject to attack by the bean aphis, *Aphis craccivora* Koch. Spraying with nicotine sulphate or pyrethrum controls it.

*Fodder and Green Manure Plants*

Fodder plants include grasses and other plants, wild or cultivated, for feeding cattle and other livestock.

Pasture grounds are in some years subject to visitations of armyworms, such as *Cirphis unipuncta* Haw. and *C. albistigma* Moore, and the swarming caterpillar, *Spodoptera mauritia* Boisd., which appear in enormous bands and wipe out grasses over large patches. The moths emerging from infested areas usually appear to migrate to distant areas for breeding.

Cultivated fodder grasses are liable to the attacks of caterpillars, but as the grasses are cut periodically for transport to markets, there is not much danger of their developing into pests. Plots of lucerne (*Medicago sativa* Linn.) and various clovers are often subject to invasion by bands of the lucerne caterpillar, *Laphygma exigua* Hübn., and at times of the caterpillars of *Prodenia litura* Fabr. Lucerne is also liable to attack by the leaf weevil, *Hypera* sp., the greenish grubs of which feed like caterpillars. Various plant lice also attack lucerne, mainly *Aphis craccivora* Koch. The roots of lucerne are often bored into by *Sphenoptera perrotetti* Guen., which also attacks groundnut stems.

In the seedling stage, *Sesbania* spp. are subject to serious damage by swarming caterpillars, such as *Prodenia* spp. The shoots of *S. grandiflora* Pers. are often bored into by the shoot weevil, *Alcidodes bubo* Fabr. Stems are liable to attack by the borer caterpillar, *Azygophleps scalaris* Fabr. Green pods of all species of *Sesbania* are infested by the seed chalcid, *Bruchophagus mellipes* Gahan, and it is often difficult to gather sufficient seed for the next crop.

Dadap (*Erythrina* spp.) is grown for shade and green manure or as standard for pepper, betel or grape vines. Young shoots are generally bored into and killed by the shoot caterpillar, *Terastia meticulosalis* Guen., which also bores into pods. A large-sized shoot bug, *Cyclopelta siccifolia* Westw., often settles on branches in large masses and causes wilting. The twig girdler beetle sometimes causes large scale girdling of branches.

In paddy-growing areas, the leaves of wild aak plants (*Calotropis* spp.) are largely used for green manuring purposes. The leaves of this plant are eaten up by the larvae of a butterfly, *Danais chrysippus* Linn. The aak grasshopper, *Poecilocerus pictus* Fabr., is specific to *Calotropis* spp. and often defoliates the plant. The fruits are oviposited into by a weevil, *Paramecops farinosa* Wied., the grubs of which burrow into the floss. Similar damage is done by the fruitfly, *Dacus longistylus* Wied., whose maggots bore into the fruits.

*Garden and Shade Plants*

Roses (*Rosa* spp.)—Roses are often defoliated in spring by cockchafer beetles. They are also subject to attack by caterpillar pests, such as *Achaea janata* Linn., *Stauropus alternus* Wlk. and *Parasa lepida* C.; and scale insects, chiefly *Aspidiotus aurantii* Mask. syn. *Aonidiella aurantii* Berl. In the sub-Himalayan areas, the foliage is liable to be damaged by the sawfly grub, *Arge* sp.

Jasmine (*Jasminum* spp.)—Besides attacks by various scale insects, mealy bugs and a tingid bug, *Leptopharsa ayyari* Drake, jasmine is liable to infestation by the jasmine bug, *Antestia cruciata* Fabr., which causes flower buds to wilt and drop off. The pest can be controlled by dusting the plant with BHC.

Lotus (*Nelumbo nucifera* Gaertn.) and water lilies (*Nymphaea* spp.)—The leaves are sometimes eaten

up by caterpillars of *Simyra conspersa* Moore and *Prodenia litura* Fabr.; leaves and flower buds are liable to infestation by the plant louse, *Rhopalosiphum nymphaeae* Linn., and thrips.

Oleander (*Nerium oleander* Linn.)—The bushes are sometimes defoliated by the caterpillars of the hawk moth, *Deilephila nerii* Linn., and a butterfly, *Euploea core* Cram. They are also liable to infestation by the scale insect, *Parlatoria oleae* Colv.

Garden crotons (*Codiaeum* spp.) are liable to serious infestation of the mealy bugs, *Icerya aegyptiaca* Dougl. and *Ferrisiana virgata* (Ckll.), and the hot-house thrips, *Heliothrips haemorrhoidalis* Bouche. The stem girdler, *Sthenias grisator* Fabr., damages the branches. The tulsi plant (*Ocimum sanctum* Linn.) is affected by a small dark lacewing bug, *Monanthia globulifera* Wlk. Artemesia plants are subject to the attack of the tingid bug, *Leptopharsa ayyari* Drake. Pruning and spraying with decoction of tobacco afford protection.

Bakul (*Mimusops elengi* Linn.) is often infested in South India by the black thrips, *Arrhenothrips ramakrishnae* Hood, which transforms attacked leaves into tubular galls.

Chrysanthemum (*Chrysanthemum* spp.)—The leaves of chrysanthemum are often damaged by the leaf folder, *Lamprosema indicata* Fabr., and by caterpillars of *Diacrisia* spp. and *Prodenia litura* Fabr. The leaf miner, *Phytomyza atricornis* Meign., sometimes causes damage to foliage. Sap-sucking insects, such as the tingid bug, *Galeatus retiarius* Dist., and the aphid, *Macrosiphoniella sanborni* Gill., also cause damage. Maggots of the fly, *Trypanaea amoena* Frgld., burrow into the flower-heads of chrysanthemums and damage flowers in North India.

Balsams (*Impatiens* spp.)—The large caterpillars of the hawkmoth, *Theretra oldenlandiae* Fabr., defoliate the plants, while the weevil, *Motialma balsaminae* Motsch., causes galls on stems and branches.

Bulbs (*Lilium* spp., *Crocus* spp., *Crinum* spp.)—The velvety black caterpillars of two moths, *Polytela gloriosae* Fabr. and *Brithys crini* Fabr., often cause serious damage to garden lilies.

*Hibiscus* spp., hollyhock (*Althaea rosea* Cav.) and sunflower (*Helianthus* spp.) are often attacked by spotted bollworms, leaf roller caterpillars, red and dusky bugs, blister beetles and scales, most of which are found on cotton. The gram caterpillar, *Heliothis armigera* Hübn., occasionally feeds on leaves and flower-heads.

Parijath (*Nyctanthes arbor-tristis* Linn.) is infested by a lasiocampid caterpillar, *Metanastria hyrtaca* Cram., and a microlepidopterous bud caterpillar, which are known to attack shoots, foliage and flower buds.

The foliage of young trees of champaka (*Michelia champaca* Linn.) grown in the rain-fed areas of the west coast, particularly Malabar, is subject to attack by the caterpillars of the swallow-tailed butterfly, *Papilio agamemnon* Linn. The caterpillars appear in large numbers during the rainy season and defoliate the branches.

*Jatropha* spp. are subject to infestation by mealy bugs, especially *Pseudococcus virgatus* Ckll., and scales, such as *Hemilecanium imbricans* Gr.

*Ixora* spp. are known to be affected by a scale insect, *Aspidiotus trilobitiformis* Gr.

Several species of *Ipomea* and *Bougainvillea* are free from serious insect pests. The stem girdler beetle, *Sthenias grisator* Fabr., damages vines during certain seasons.

Ornamental plants like cycads and ferns, grown in ferneries and glass houses, are infested by scale insects, chiefly *Chionaspis dilatata* Gr.

*Millingtonia hortensis* Linn. f. is subject to attack by the teak defoliator, *Hyblaea puera* Cram.

Infestation by caterpillars like *Eligma narcissus* Cram. and *Atteva* spp. causes defoliation of large trees of *Ailanthus excelsa* Roxb. The tree is sometimes heavily affected by the scale insect, *Hemilecanium imbricans* Gr.

The foliage of neem (*Azadirachta indica* A. Juss.) is damaged by a nettle grub, *Thosea* sp.; the tea mosquito, *Helopeltis antonii* Sign., punctures young flush and causes twigs to dry up. In parts of South India, the neem tree is infested by dense colonies of the neem mealy scale, *Pulvinaria maxima* Gr., which causes premature leaf drop.

The shoot borer, *Tonica niviferana* Wlk., is a serious pest of the silk cotton tree (*Salmalia malabarica* Schott & Endl.). The pod borer, *Mudaria cornifrons* Moore, feeds on tender seeds and damages the lint.

Beefwood tree (*Casuarina equisetifolia* Linn.) plantations are sometimes attacked by colonies of mealy bugs, such as *Icerya aegyptiaca* Dougl., *I. formicarium* Newst. and *Pericerya* (*Icerya*) *purchasi* (Mask.), and also *Labioproctus* spp. Stems are liable to attack by the grubs of the beetle, *Coelosterna scabrator* Fabr., which also rings and mills the twigs.

Siris (*Albizzia lebbek* Benth.) shoots are liable to infestation by a psyllid bug, *Arytaina* sp., which causes twisting and bunching of shoots; the ceramby-

cid borer, *Xystrocera globosa* Oliv., is a serious pest of this tree.

Babul (*Acacia arabica* Willd.) is often infested by the faggot worm, *Clania cramerii* Westw., and the scale insect, *Anomalococcus indicus* Gr., in South India. The grubs of *Coelosterna spinator* Fabr. bore into the stems and adults often strip the bark off young twigs.

Bamboo culms are attacked by maggots of *Chelyophora* spp. and by the culm weevil, *Cyrtotrachelus dux* Boh., the grubs of which bore through shoots and destroy growing points. The culms are also subject to infestation by *Oregma bambusae* Buckt. and *Ochrophara montana* Dist., the latter a pentatomid bug which breeds in millions on flowering bamboos. Dry bamboos are liable to attack by *Stromatium barbatum* (Fabr.) and *Dinoderus* spp.

*Fruits and Fruit Trees*

Citrus, mango, banana, guava, sapota and a few other tropical and sub-tropical trees are cultivated on a large scale in the plains in different parts of the country, while apple, pear, peach, almond and walnut are usually grown in hilly areas.

The main pests of seedlings and potted grafts of citrus trees are the leaf miner, *Phyllocnistis citrella* Staint., which often retards the growth of plants, and the caterpillar of lemon butterfly, *Papilio demoleus* Linn., which completely defoliates young plants ; the latter is also a serious pest of plants in bearing. Numerous sucking pests reduce the yields of citrus crops : the most serious among them is the citrus psylla, *Diaphorina citri* Kuw., which is often destructive to orchards in North India, especially in the Punjab. Several species of mealy wings infest orange and other citrus varieties ; *Dialeurodes citri* Ashm. causes loss of sap and is responsible for a marked fall in yields. The Mediterranean fruitfly, *Ceratitis capitata* Wied., is absent in India, but the local species, *Dacus ferrugineus* Fabr., *D. zonatus* Saund. and *D. incisus* Wlk., cause considerable damage to crops in several parts of India. The main pests of ripening fruits are the fruit sucking moths, *Othreis fullonia* Clau. and *O. materna* Linn., which drill holes into the fruit rind and suck up the juice : affected fruits develop fruit-rot and drop down. Among the stem borers which cause serious damage, mention may be made of the twig borer, *Chelidonium cinctum* Guer., in Mysore and *C. argentatum* Dalm. in Kerala : *Stromatium barbatum* (Fabr.) is a serious pest in Nagpur ; *Monochamus versteegi* Rits. is a destructive borer in Bengal, Bihar and Assam. The bark eating caterpillar, *Indarbela quadrinotata* Wlk., is a serious pest of older plantations in Nagpur. Prompt hand picking of eggs and caterpillars is recommended as a control measure. Affected leaves are either clipped or cleared of caterpillars and plants are treated with a repellent or insecticidal spray. Ripened fruits are covered by bamboo baskets to keep away sucking moths. The application of DDT or BHC sprays or dusts are effective against several of these pests.

The mango is a long lived tree and unless protected against pests, the yield may be seriously affected. The foliage of mango trees is often infested by the castor slug, *Parasa lepida* Cram., and the wild silk moth, *Cricula trifenestrata* Helf. Tender leaves are destroyed by the leaf cutting weevil, *Deporaus marginatus* Pasc., and the flea weevil, *Rhynchaenus mangiferae* Mshll. In some cases, leaves are webbed up by a gregarious caterpillar, *Orthaga exvinacea* Hmpsn., which ultimately causes whole bunches to dry up. Mango is also subject to attack by shoot borers and gall insects. In parts of Bihar and Uttar Pradesh, the trees are affected by a serious shoot gall disease caused by the nymphs of a psyllid bug, *Apsylla cistellata* Buckt. Young nymphs of this psyllid infest nascent leaf buds at the tip of the shoot or the axils of leaves, with the result that instead of flushes, a conical casket-shaped gall is formed. The most serious pests of the mango are the mango hoppers, *Idiocerus niveosparsus* Leth., *I. atkinsoni* Leth. and *I. clypealis* Leth., which infest inflorescences and prevent fruit setting. The first of these species occurs in South India while the other two in North India. The pests are controlled by spraying trees with DDT. The tender mango shoots and inflorescences are sometimes seriously infested by the mango mealy bug, *Drosicha mangiferae* Gr., which prevents the setting of fruits and causes their premature fall. The pest is controlled by grease banding of the tree trunks to prevent ascent of the nymphs or by a spray of Diazinon.

Young mango fruits are liable to attack by the mango stone weevil, *Cryptorhynchus mangiferae* Fabr., the grubs of which develop in the kernel of the stone and pupate inside : the weevils emerge when the fruit is ripe. The grubs of *C. frigidus* Fabr. feed on fruit pulp, and the fruits later drop to the ground. Maturing fruits are subject to infestation by the fruitflies, *Dacus ferrugineus* Fabr., *D. zonatus* Saund. and *D. dorsalis* Hendel ; the maggots tunnel into the pulp and spoilage sets in. Destruction of weevils from fallen fruits, disposal of refuse and

general cleanliness of the orchard help to check the pests.

The mango tree is liable to attack by various stem borers, of which *Batocera rufomaculata* deG. is the most common. The grubs of *Monochamus versteegi* Rits. infest trees in eastern India. *Acanthophorus serraticornis* Oliv., a large beetle found in North India, burrows through the soil and attacks roots. Affected trees are felled and converted before the beetles emerge from the tunnels. Sometimes young mango plantations are severely damaged by several scale insects.

The leaves of banana (*Musa* spp.) are sometimes attacked by several caterpillars, e.g. *Diacrisia obliqua* Wlk., *Pericallia ricini* Fabr., *Parasa lepida* Cram. and *Prodenia litura* Fabr. The plant is also liable to infestation by the banana aphis, *Pentalonia nigronervosa* Ckll., which is the carrier of the bunchy-top virus. The most serious pest of banana, however, is the banana root-stock weevil, *Cosmopolites sordidus* Germ., which lays eggs at the base of the stem : the grubs tunnel into the rootstock. This pest has now spread all over the tropics. Another weevil, banana borer weevil, *Odoiporus longicollis* Oliv., found in Bihar, U.P., Bengal and Assam, tunnels into the pseudostem and ultimately kills the plant.

The most serious pest of guava (*Psidium guajava* Linn.) is the mealy scale, *Pulvinaria psidii* Mask. : affected plants are covered with a sooty mould or a greyish meal. Maggots of the fruitfly, *Dacus ferrugineus* Fabr., and the caterpillars of the castor capsule borer, *Dichocrocis punctiferalis* Guen., bore into the fruits and cause spoilage. The tea mosquito, *Helopeltis antonii* Sign., is known to puncture young shoots and also to cause scabs on fruits in South India. Removal and destruction of affected fruits and spraying of affected plants with BHC or Diazinon may help to keep down the fruitfly and mealy scale pests respectively.

The most serious pest of pomegranate (*Punica granatum* Linn.) is the pomegranate butterfly, *Virachola isocrates* Fabr., the caterpillars of which bore into the fruits and eat away the seeds. The pest is common throughout the plains. Caterpillar of another butterfly, *Epijarbas anchus* Fruh., causes similar damage to fruits in Kumaon and Dehra Dun. Developing fruits are covered by paper or muslin bags to prevent the butterfly from laying eggs. Destruction of damaged fruits and hand netting of butterflies and destroying them are suggested as control measures.

One of the worst pests of grape vine (*Vitis vinifera* Linn.) is the tiny flea beetle, *Scelodonta strigicollis* Motsch. (Bombay—*Udadya*), which lives on the bark and attacks leaf and flower buds in spring. Eggs are laid on the bark and grubs, on hatching, drop to the ground and feed on the roots of the vine. The foliage is subject to attacks by the sphingid caterpillar, *Hippotion celerio* Linn., which may at times entirely defoliate vines. The vine is also liable to infestation by a species of thrips, *Rhipiphorothrips cruentatus* Hood, scales and mealy bugs, e.g. *Aspidiotus lataniae* Sign., *Lecanium longulum* Dougl. and *Pulvinaria maxima* Gr. Fruits are attacked by caterpillars of the plume moth, *Oxyptilus regulus* Meyr., found in Mysore and Ceylon. The grape vine girdler beetle, *Sthenias grisator* Fabr., lays eggs in the distal part of the branch, which later wilts and dries up. The grape vine chafer grubs, *Adoretus* spp., affect the roots. Destruction of ringed branches and collection of beetles afford control against the girdler beetle ; in other cases, spraying with DDT, nicotine sulphate or fish oil rosin soap helps to keep down the pests.

Cultivated fig (*Ficus* spp.) is occasionally subject to attack by the caterpillars of *Aganais ficus* Fabr., *Phycodes minor* Moore and *P. radiata* Ochs., which cause defoliation : the stem borer, *Batocera rufomaculata* deG., is a serious pest in some localities. The pests can be checked by mechanical methods or by dusting with BHC.

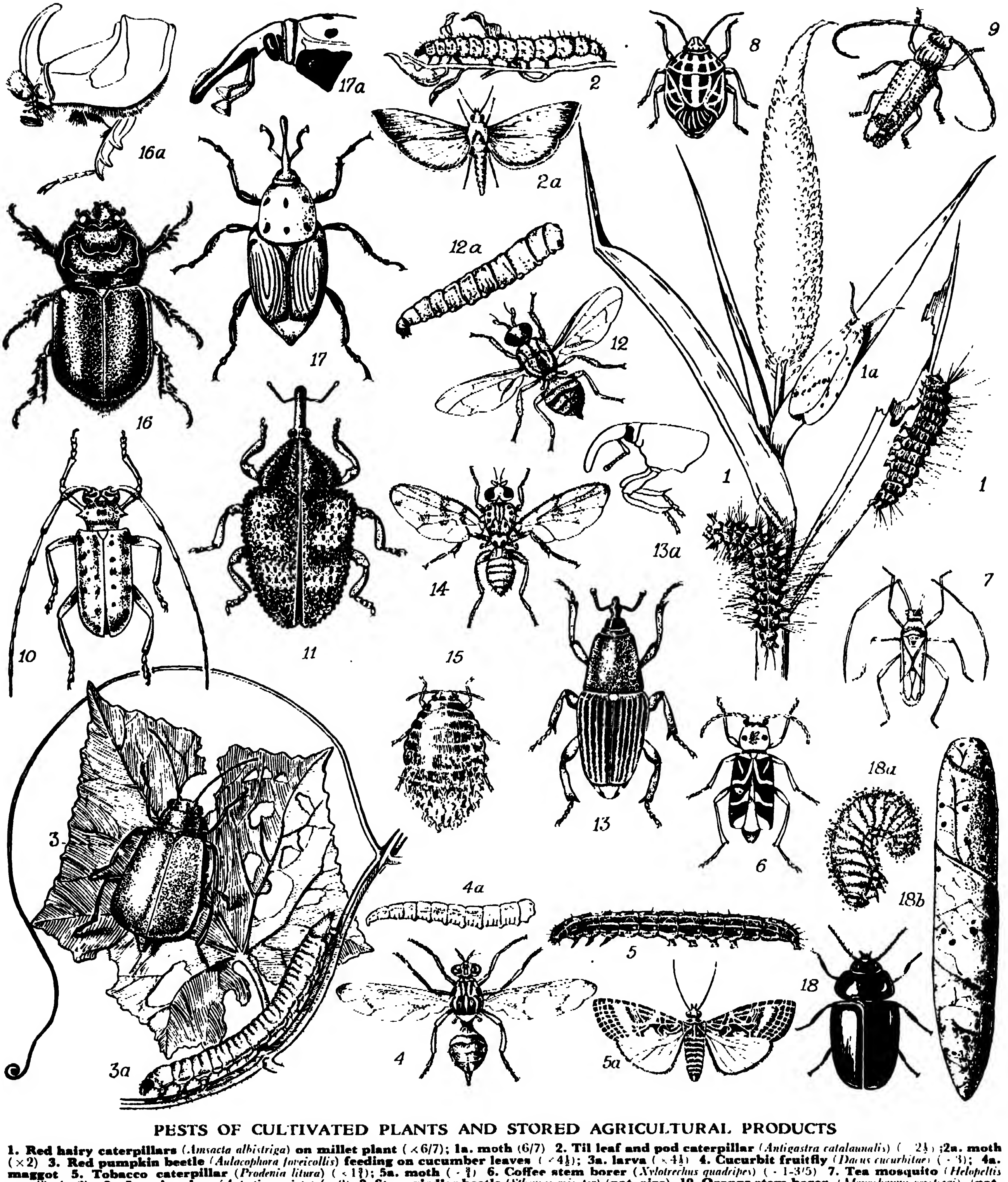
A small weevil, *Ochyromera artocarpi* Mshll., often infests buds and young fruits of jack tree (*Artocarpus integra* Merrill) in western ghats and parts of Mysore : affected parts drop off from the tree. A caterpillar, *Margaronia caesalis* Wlk., bores into the stem. Fumigation of borer holes with petrol or calcium cyanide paste is recommended for its control. Destruction of infested and fallen buds and fruits and collection and destruction of weevils afford preventive checks against the bud weevil.

The fruits of custard apple (*Annona squamosa* Linn.) are liable to infestation by the mealy bug, *Ferrisiana virgata* (Ckll.).

A humped caterpillar, *Carea subtilis* Wlk., attacks young plants of jamun (*Syzygium cumini* Skeels) and causes defoliation. Stones of fruits are often infested by the weevil, *Balaninus C-album* Fabr.

Infestation by caterpillars of *Nephopteryx eugraphella* Rag. causes wilting of shoots of sapota (*Achras zapota* Linn.).

The principal pests of the ber tree (*Zizyphus* spp.)




## PESTS OF CULTIVATED PLANTS AND STORED AGRICULTURAL PRODUCTS

**1. Red hairy caterpillars** (*Amsacta albistriga*) **on millet plant** (×6/7); **1a. moth** (6/7) **2. Til leaf and pod caterpillar** (*Antigastra catalaunalis*) (×2½); **2a. moth** (×2) **3. Red pumpkin beetle** (*Aulacophora foveicollis*) **feeding on cucumber leaves** (×4½); **3a. larva** (×4½) **4. Cucurbit fruitfly** (*Dacus cucurbitae*) (×3); **4a. maggot 5. Tobacco caterpillar** (*Prodenia litura*) (×1⅞); **5a. moth** (×⅞) **6. Coffee stem borer** (*Xylotrechus quadripes*) (×1-3/5) **7. Tea mosquito** (*Helopeltis antonii*) (×2) **8. Jasmine bug** (*Antestia cruciata*) (×2) **9. Stem girdler beetle** (*Sthenias grisator*) **(nat. size) 10. Orange stem borer** (*Monochamus versteegi*) **(nat. size) 11. Mango stone weevil** (*Cryptorrhynchus mangiferae*) (×4) **12. Mango fruitfly** (*Dacus ferrugineus*), **female** (×3½); **12a. maggot 13. Banana root-stock weevil** (*Cosmopolites sordidus*) (×3); **13a. side view of head 14. Ber fruitfly** (*Carpomyia vesuviana*) (×4) **15. Woolly aphis of apple** (*Eriosoma lanigerum*) **wingless female** (×10) **16. Rhinoceros beetle** (*Oryctes rhinoceros*) **(nat. size); 16a. side view of head of male 17. Red palm weevil** (*Rhynchophorus ferrugineus*) (×1-1/6); **17a. side view of head of male 18. Cigarette beetle** (*Lasioderma serricorne*) (×8); **18a. larva covered with particles of tobacco leaf** (×8); **18b. damaged cigar with exit holes of the beetle**

are the ber fruitfly, *Carpomyia vesuviana* Costa, and the boring caterpillar, *Meridarchis scyrodes* Meyr.

The main pests of litchi (*Litchi chinensis* Sonn.) are the litchi leaf-curling mite, *Eriophyes* sp., and the bark eating caterpillar, *Indarbela quadrinotata* Wlk. The latter also attacks loquat (*Eriobotrya japonica* Lindl.). Spraying with lime-sulphur controls the mite while fumigation of borer holes with petrol is effective against the bark eating caterpillar.

Roots of mulberry (*Morus* spp.) trees are at times subject to attacks by beetle borer grubs.

The leaves of cashewnut tree (*Anacardium occidentale* Linn.) are liable to infestation by colonies of the cacao thrips, *Selenothrips rubrocinctus* Giard. Young shoots are often punctured by the mosquito bug, *Helopeltis antonii* Sign.

Pineapple (*Ananas comosus* Merrill) is usually free from insect attacks. Occasional damage by the mealy bug, *Pseudococcus brevipes* Ckll., has been reported.

Singhara or water nut (*Trapa* spp.) is often seriously damaged by the beetle, *Galerucella birmanica* Jacoby.

Amla (*Emblica officinalis* Gaertn.) is affected by a caterpillar, *Betousa stylophora* Swinh., which causes round galls in shoots. The mealy bug, *Pseudococcus* sp., attacks tender parts of the plant. The bluish metallic green bug, *Scutellera nobilis* Fabr., sucks the fruits.

Wood Apple (*Feronia limonia* Swingle) and bael or bilwa (*Aegle marmelos* Correa) are affected by the caterpillars of *Euzophera plumbeifasciella* Hmpsn. and *Argyroploce carpophaga* Walsm., which infest the fruits and bore into the pulp. Two species of flea beetles, *Clitea picta* Baly in North India and *C. indica* Jacoby in South India, breed on young flushes of bael and cause much damage.

Papaya (*Carica papaya* Linn.) is not affected by any serious pests in India.

The cultivation of apple, pear, peach and almonds is restricted to the hilly areas. Some of the pests, e.g. San Jose scale and woolly aphis of apple, commonly noted on these fruits in Europe and Western Asia, have been recorded in India: there are still others which have not as yet found entrance into this country and it is necessary to tighten quarantine restrictions at the frontiers to prevent their introduction into India.

The following are among the pests of West Asia affecting apple, peach and almond in parts of West Pakistan, but which have not so far been reported from fruit growing regions in India: Apple bud moth, *Spilonota ocellana* Schiff.; white tussock moth of apple, *Euproctis signata* Blanch.; ermine moth, *Hyponomeuta padella* Linn.; codling moth of apple, *Carpocapsa pomonella* Linn.; apricot shoot borer, *Anarsia lineatella* Zell.; shot hole borer, *Scolytus amygdali* Guer.: apricot chalcid, *Eurytoma samsonovi* Vass.; black stem-aphis of peach, *Pterochlorus* (*Lachnus*) *persicae* Chol.; olive psylla, *Euphyllura olivina* (Costa); and olive fruitfly, *Dacus oleae* Fabr. var. *asiatica* Silv.

The San Jose scale, *Quadraspidiotus perniciosus* Comst., is a serious pest of apple in Kashmir and has already spread into many parts of India; the woolly aphis of apple, *Eriosoma lanigerum* Hausm., has similarly become widespread in India. The pear psylla, *Psylla pyricola* Först., commonly found in N.W. Frontier Province has also been recorded from Kumaon in Uttar Pradesh. In Assam, apples are liable to infestation by two fruit weevils, *Dyscerus fletcheri* Mshll. and *D. malignus* Mshll.; a shoot borer, *Alcidodes mali* Mshll.: and a twig girdler, *Linda nigroscutata* Fairm. The beetle, *Aeolesthes sarta* Solsky, which bores into the stems of the apple plant, is found in Kashmir. *Dorysthenes hugelii* Redt. infests the roots of apple plants in Kumaon, the Punjab and Himachal Pradesh. In these States, apple orchards are also damaged by the tent caterpillar, *Clisiocampa indica* Wlk., and a number of leaf-defoliating and fruit-eating beetles, viz. *Melolontha*, *Adoretus* and *Anomala* spp.

Peaches, almonds and apricots are subject to the attack of three aphids, viz. green aphis, *Myzus persicae* (Sulz.), leaf-curling aphis, *Anuraphis helichrysi* (Kalt.), and mealy aphis of peach, *Hyalopterus arundinus* Fabr. *Sphenoptera lafertei* Thom. is a serious pest of peach, pear and plum in Kashmir, Uttar Pradesh and Delhi. *Dacus zonatus* Saund. and *D. ferrugineus* Fabr. damage peach fruits. The San Jose scale and another scale, *Pseudaulacaspis pentagona* Targ., also attack peach.

The walnut (*Juglans regia* Linn.), which grows wild throughout the Himalayas and hills of Assam at elevations of 3,000 to 11,000 ft., is subject to attack by a weevil, *Alcidodes porrectirostris* Mshll., which emerges from hibernation in spring, feeds on leaves and flower buds, and infests young fruits.

Coconut (*Cocos nucifera* Linn.) and areca nut (*Areca catechu* Linn.) are the chief palms cultivated in India. Palmyra (*Borassus flabellifer* Linn.) and wild date (*Phoenix sylvestris* Roxb.) are found growing semi-wild in many places. The black-headed cater-

pillar pest of coconut, *Nephantis serinopa* Meyr., is also known to attack palmyra, wild date and talipot (*Corypha umbraculifera* Linn.). The rhinoceros beetle, *Oryctes rhinoceros* Linn., bores into the base of top fronds and causes serious damage: the beetle breeds in dead trunks and farmyard manure. The red palm weevil, *Rhynchophorus ferrugineus* Oliv., is a serious pest of date and sago palms (*Metroxylon* spp.): the weevil is attracted to the palms by the odour of the oozing juice; it lays eggs in stems of injured or diseased palms and eventually kills the top shoots. The plant louse, *Cerataphis lataniae* Boisd., is sometimes found on young palms and has often proved a serious pest of areca palms in Mysore. The desert locust, *Schistocerca gregaria* Forsk., and the Bombay locust, *Patanga succincta* Linn., have been recorded as causing defoliation of coconut and areca palms on the west coast. Date palms in N.W. India are also known to have been similarly attacked by the desert locust. Preventive measures consist chiefly in locating breeding places and destroying the pests in the early stages. Crownless and felled trees must be promptly disposed of, since they serve as breeding materials for pests. Insecticidal sprays have proved effective in some cases. During certain seasons, braconid wasps act as natural enemies of black-headed caterpillars and afford some control.

*Locusts*

Locusts (Order *Orthoptera*, family *Acrididae*) are grasshopper-like insects, though bigger in size, at times multiplying greatly and migrating long distances in swarms. They are voracious eaters and cause immense destruction of economic plants. Locust species occur in two phases, solitary and gregarious, connected by transitional forms. The two phases are convertible: the progeny of the solitary phase, if reared in crowds, gets converted into the gregarious phase and the gregarious type, if reared in isolation, reverts to the solitary phase. Out of a dozen species of locusts known from different parts of the world, the more serious pests in the Indian region are the desert locust, *Schistocerca gregaria* Forsk., the migratory locust, *Locusta migratoria* Linn. and the Bombay locust, *Patanga succincta* Linn. Detailed information on the locust species will be found in the article on locusts.

PESTS OF TIMBER TREES

Insect pests of forest trees may be grouped under four main categories, namely borers, defoliators, sap-suckers and other pests.

*Borers*

The borers are mostly beetles (*Coleoptera*), moths and butterflies (*Lepidoptera*). Both adults and larvae of beetles and larvae of moths bore into wood; beetles lay eggs on the barks of trees or inside the wood in galleries. Some adult forms belonging to *Hymenoptera* and worker and soldier castes of termites (*Isoptera*) also act as borers.

The more important coleopterous borers are the following: *Ghoon* or powder-post borers of dry and semi-dry wood attack felled trees and dry timber, both logs and planks; the beetles are dark brown in colour and of small size (length, 2–8 mm.). *Dinoderus brevis* Horn, *D. minutus* Fabr. and *D. ocellaris* Stephens attack bamboos. Adult beetles bore through cut or abrased surfaces; pairing takes place inside the tunnels where the eggs are also laid. The larvae bore further up and down until the entire bamboo is riddled through and pupation also occurs in hollow

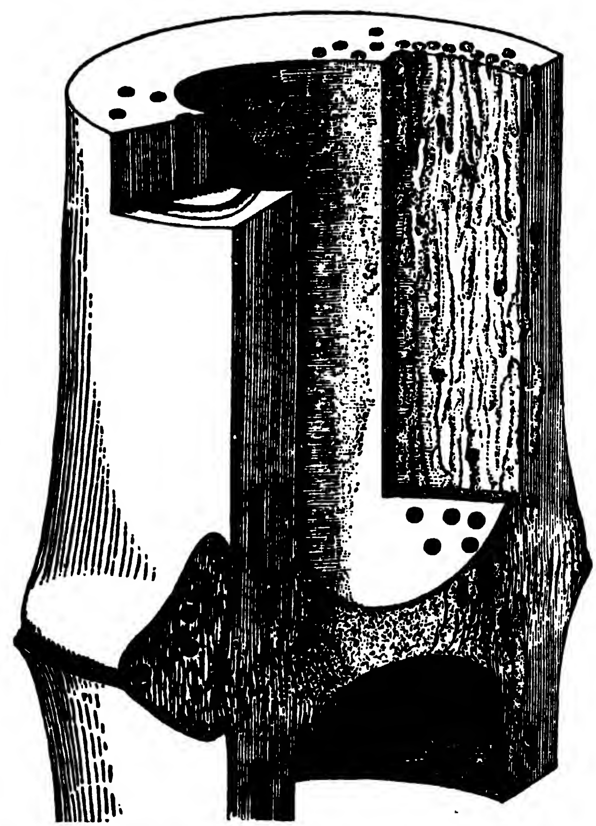


FIG. 116. DINODERUS SP. (GHOON) ATTACKING BAMBOO (DENDROCALAMUS STRICTUS NEES)

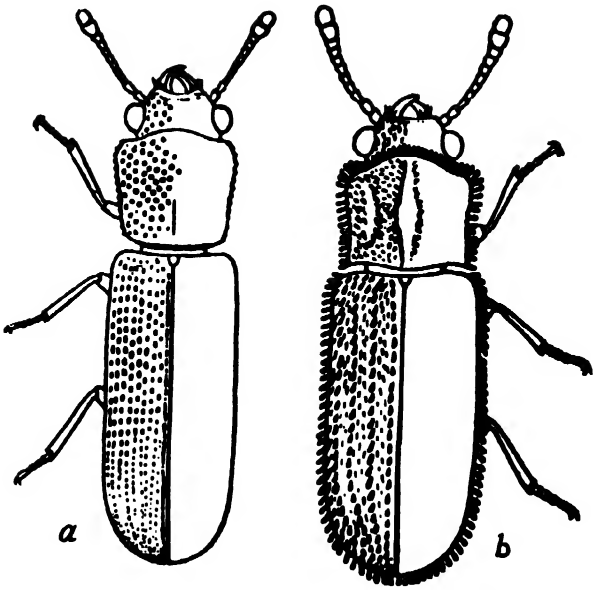



FIG. 117. BEETLES OF: (a) LYCTUS AFRICANUS LESNE (× 14) (b) MINTHEA RUGICOLLIS WLK. (× 18)

tunnels. The adult beetle may either fly away or breed a second generation inside old tunnels. There are at least three annual generations, the peak periods of emergence of adults being March–April, June–July and September–October. Control during short periods of storage (up to 1 year) in depots is possible by treating (dipping or spraying) the culms with 0.5–1% BHC or 5-10% DDT. Longer protection is obtained by treatment with coal tar creosote which, to be effective, should be allowed to penetrate into the tissues. Other serious bostrychid pests of timbers are: *Heterobostrychus aequalis* Waterh., *Lyctus brunneus* Stephens, *L. africanus* Lesne, *Minthea rugicollis* Wlk., *Rhizopertha dominica* Fabr., *Sinoxylon anale* Lesne, *S. crassum* Lesne and *Xylothrips flavipes* Illi.

Two inspections of storage depots, in March and October, are desirable to ensure protection of stock from borer attack. Casein-lime glues used for plywood usually contain an antiseptic like copper chloride, sodium fluoride or sodium arsenate, which are slightly toxic to borer larvae. Phenol-formaldehyde resin binders are impervious to fungi, termites and bostrychid borers. Dipping in boric acid or zinc chloride or spraying stacks with strong solutions of the same chemicals checks damage to veneers and splints used for matches. Full protection of pith from *Rhizopertha dominica* is obtained by 10% solution of sodium fluosilicate in water or 1 part of copper sulphate with 3 parts of arsenic pentoxide in 4% aqueous solution. General cleanliness of stock yards and depots (freedom from felling refuse or fuel stacks) keeps off *Sinoxylon* spp.

Tree borers—*Cerambycidae* constitutes an important family of tree borers. The beetles are large (length, 10–50 mm.) and possess long antennae. The sal borer, *Hoplocerambyx spinicornis* Newm., is the most serious pest of sal (*Shorea robusta* Gaertn. f.) and a few other trees. The beetle is 25–50 mm. long and is dark brown in colour with a single annual generation. Soon after emergence from trees, with the onset of and during the monsoon (June–September), the beetles lay eggs in the crevices of the bark of well grown, but sickly, sal trees; young trees are usually free from attack, while healthy trees are attacked only during an epidemic. Eggs hatch in 2 to 3 weeks: the grub bores into the sapwood and later, as it grows, penetrates into the heartwood where it makes long, sub-cylindrical galleries throughout the trunk and main branches. Single trees have been known to harbour as many as 1,000 larvae, though ordinarily the number is much less. The white, cylindrical grub usually grows to its full size (size of the small human finger) by November. Pupation occurs near the outer surface of the tree in a

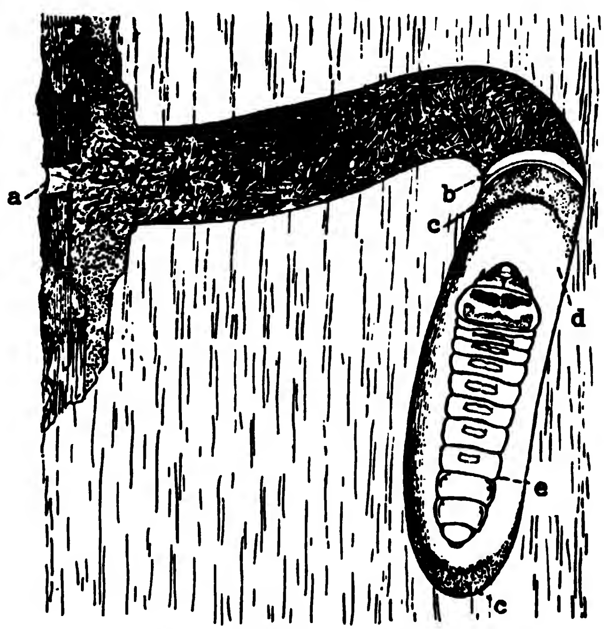



FIG. 118. LONGITUDINAL SECTION THROUGH LARVAL AND PREPUPAL TUNNEL AND PREPUPAL CHAMBER OF THE SAL BORER, HOPLOCERAMBYX SPINICORNIS NEWM., IN SAL (SHOREA ROBUSTA GAERTN. f.) SHORTLY AFTER CONSTRUCTION OF OPERCULUM (a) EJECTION HOLE IN BARK (b) CALCAREOUS OPERCULUM (c) WOOD DUST LINING THE CAVITY (d) PUPAL CHAMBER (e) PREPUPAL STAGE OF RESTING LARVA (× ½)

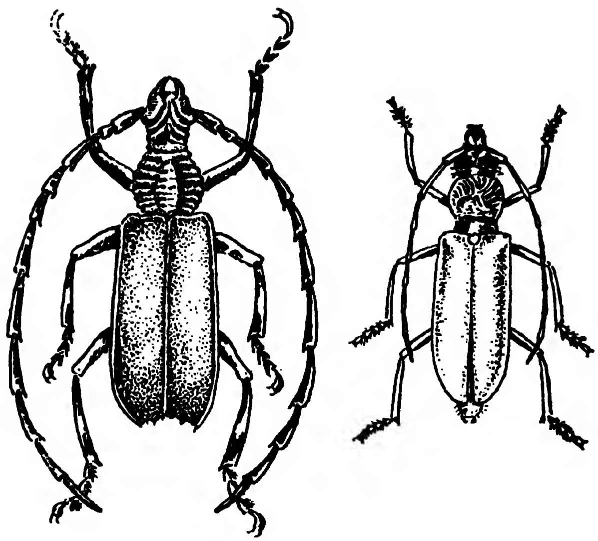



FIG. 119. BEETLES OF: (a) HOPLOCERAMBYX SPINICORNIS NEWM. (NAT. SIZE) (b) AEOLESTHES HOLOSERICEA FABR. (× 1½)

chamber, which is plugged over with a helmet-shaped calcareous operculum. The beetle, which reaches adulthood in May–June, remains quiescent for 2 to 3 weeks, emerging with the first shower of the monsoon rain in June–July. Control is achieved mainly through sylvicultural and mechanical means; the forest is kept clean of dead wood and refuse and opportunities for breeding of the beetle are eliminated; the mechanical means involve attracting the beetles to felled sal trees to catch and kill them.

Other important cerambycid pests are: *Aeolesthes holosericea* Fabr., which resembles *Hoplocerambyx spinicornis* Newm. and attacks several species of dead and dying trees; *Batocera horsfieldi* Hope, a stem borer of oak, and *B. rufomaculata* deG., a stem borer of seemul (*Salmalia malabarica* Schott & Endl.), walnut and several other trees; *Coelosterna scabrator* Fabr., a root borer of babul, casuarina and ber trees, especially the first named to which it causes serious damage in Peninsular India; *Dihammus cervinus* Hope, which causes swollen canker in saplings of teak; *Stromatium barbatum* (Fabr.), a borer of dry timber (logs, planks, furniture) with a life history covering 1 to 10 years; and *Xylotrechus smei* Lap. & Gory, a borer of several species of newly felled trees.

The more important pestiferous species of snout beetles (*Curculionidae*, 5–20 mm. long) are: *Cyrtotrachelus dux* Boh., a borer of sprouting bamboos; *Pagiophloeus longiclavis* Mshll., the mahogany collar borer of South India; and *Rhynchophorus ferrugineus* Oliv., the red weevil borer of coconut palm. The mahogany collar borer lays eggs singly in wounds on living boles and usually near ground level; the larvae bore into the sapwood, causing canker at the base of stem and ultimately the death of sapling; two or three annual generations occur and beetles emerge all the year round. Hand picking and destroying of beetles at the beginning of the monsoon (June–August) is helpful to check the pests. Dead palms and logs which remain unused in the construction of buildings and bridges should be destroyed lest they afford breeding material for beetles. Old leaves are cut off and wounds of any kind are tarred. Larvae should be killed by fumigation of wood crevices.

The heartwood borer, *Attractocerus reversus* Wlk., is a serious pest of salai (*Boswellia serrata* Roxb.), a timber used for cheap boxes and packing cases and also for the manufacture of paper. Felled wood should be stored with sterilised ends and the barks should be swabbed with creosote oil mixture which keeps them alive and green.

Pin-hole and shot-hole borers (*Platypodidae* and *Scolytidae*) are tiny sub-cylindrical beetles causing considerable damage to wood. They are so named because of the nature of damage they cause. Some are known as ambrosia beetles because they promote fungus growth in galleries made by them in the wood. The galleries have a distinctive and rather decorative pattern and consist of a number of horizontal

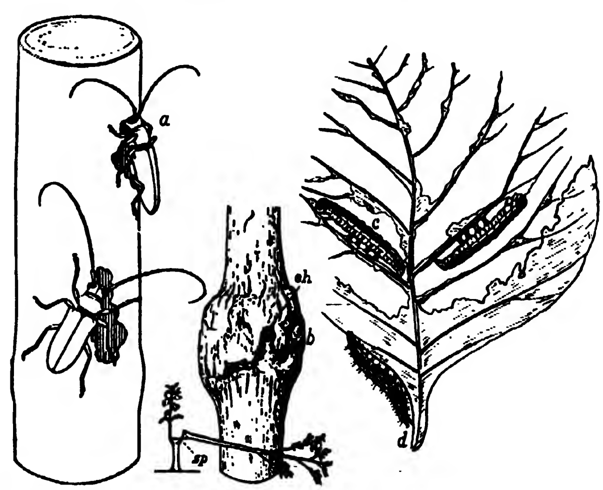



FIG. 120. (a) BEETLES OF DIHAMMUS CERVINUS HOPE (× 4/5), GNAWING PATCHES ON BARK OF THE STEM OF TEAK (TECTONA GRANDIS LINN. f.) (b) SWOLLEN CANKER CAUSED BY THE BEETLE ON SAPLING OF TEAK; eh: EXIT HOLE; sp: SAPLING BROKEN (c) CATERPILLAR OF HYBLAEA PUERA CRAM. DAMAGING TEAK LEAF (× 1½) (d) CATERPILLAR OF HAPALIA MACHAERALIS WLK. DAMAGING TEAK LEAF (NAT. SIZE)

galleries leading on either side from a central parental gallery.

Several species of *Crossotarsus* (*Platypodidae*) occurring in India are polyphagous. *Diacavus furtivus* Samp. bores into sal wood; *Platypus biformis* Chapuis bores pines; *P. solidus* Wlk. is polyphagous.

*Coccotrypes* spp. (*Scolytidae*) bore into fruits and seeds of *Areca catechu* Linn. and other trees; *Ips longifolia* Steb. bores conifers in the Himalayas; *Sphaerotrypes siwalikensis* Steb. is a borer of sal trees; *Xyleborus testaceous* Wlk. and other species of the genus are common tree borers.

Coal tar, carbolineum oil and other mineral oils, water-soluble salts, cow dung and similar deterrents are used to deter pin-hole borers in tropical forests. Injection of arsenicals does not prevent borer attack. In areas of heavy infestation of shot-hole borers, the whole crop of berries and flowers is burnt. The application of poisonous paints to kill borers after pruning is expensive.

Among the other families of coleopterous borers, *Anobiidae*, *Anthribidae* and *Buprestidae* contain serious pests of forest plants. *Chrysomelidae* includes the common bamboo borer, *Estigmena chinensis* Hope. *Scarabaeidae* and the sub-families *Melolonthinae* and *Rutelinae* include the cockchafer groups, whose grubs live in soil and cut roots and stems of seedlings and saplings.

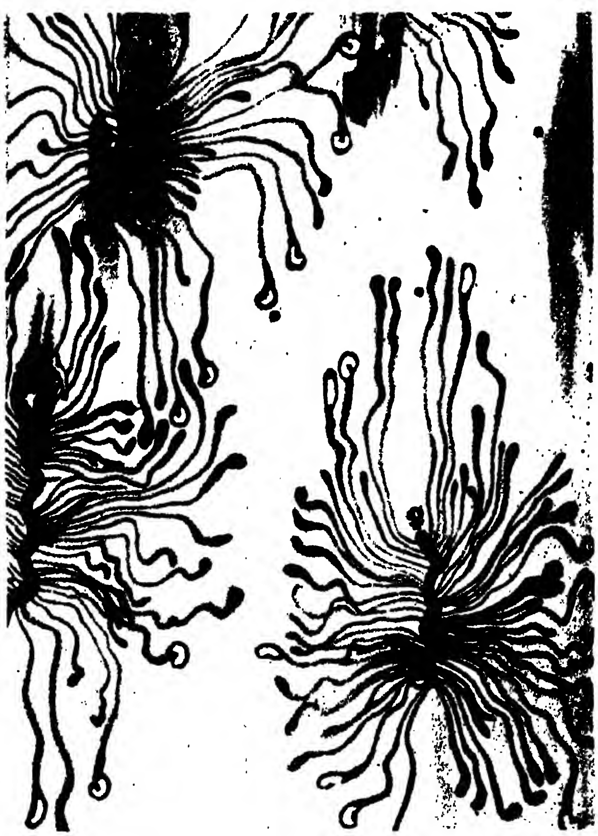


FIG. 121. GALLERY SYSTEM OF AMBROSIA BEETLES ON SURFACE OF BARK STRIPPED FROM LOG OF CEDRUS DEODARA LOUD.

While the larvae of the majority of moths and butterflies (*Lepidoptera*) are defoliators, those of a few families are borers of wood. The shoot borer, *Dichomeris eridantis* Meyr. (*Gelechiidae*), is a pest of shisham (*Dalbergia* spp.); it has seven annual generations in North India.

*Hypsipyla robusta* Moore (*Pyralidae*), the borer of cedar (*Cedrus deodara* Loud.), toon (*Cedrela toona* Roxb.) and mahogany (*Swietenia mahogani* Jacq.), is also a borer of fruits and seeds. Five annual generations are reported on toon in North India. Control is achieved by silvicultural methods; close spacing checks its increase. Mature caterpillars are trapped in bands and destroyed. Predators derived from weeds and shade crops help in the biological control of the pest.

Borers of boles and branchwood—*Xyleutes ceramica* Wlk. (*Cossidae*) is the beehole borer of teak in Burma; it has not so far reached India and Ceylon. *Zeuzera coffeae* Nietner is the red borer of coffee in South India. *Phassus malabaricus* Moore (*Hepialidae*) and *Indarbela quadrinotata* Wlk. (*Indarbelidae*) are polyphagous. *Hapsifera rugosella* Staint. (*Tineidae*) bores through dead bark of many species of trees.

The greasy cutworm, *Agrotis ypsilon* Rott. (*Noctuidae*), is a common polyphagous pest of seedlings in gardens and forest nurseries, especially in the Himalayas and in the Indo-Gangetic plain; it also occurs in many other countries. The larvae live in soil, emerge at night and cut seedlings at the ground level. Collection and destruction of cutworms are recommended as a control measure; irrigation also affords a means of eradicating the worms in nurseries. Dusting seed beds thickly with wood ashes or a mixture of quick lime and ashes acts as a physical barrier to cutworms.

The larva of the wood wasp, *Sirex imperialis* Kirb. (Order *Hymenoptera*, family *Siricidae*), bores tunnels into logs of conifers in the Himalayas. The adults of carpenter bees, *Xylocopa* spp. (*Xylocopidae*), bore into dead branches, posts and rafters of several species of timber.

Termites (*Isoptera*) of the family *Kalotermitidae*

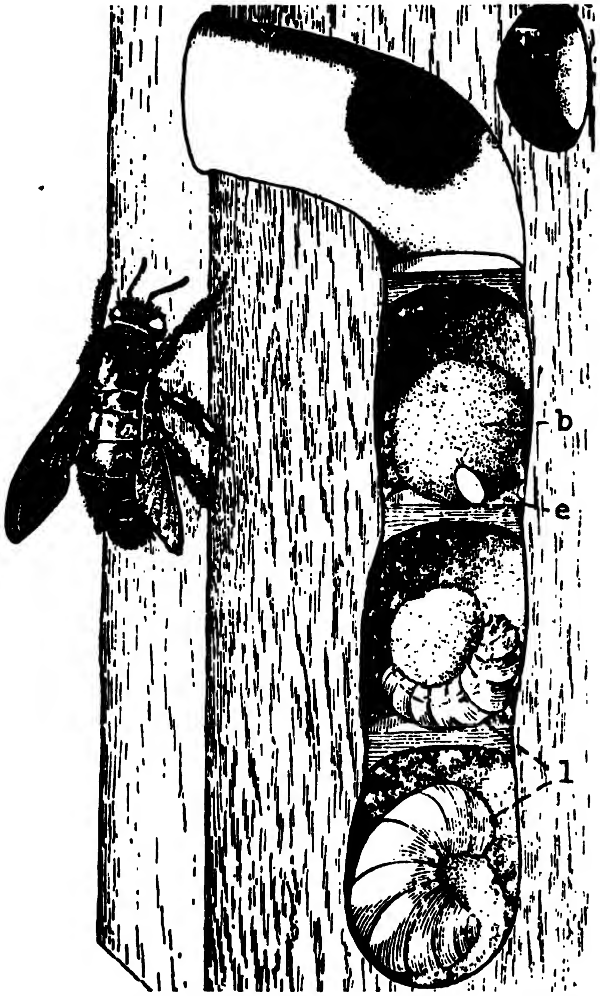



FIG. 122. SECTIONAL VIEW OF TUNNEL BORED INTO WOODEN POST BY ADULT OF CARPENTER BEE (XYLOCOPA SP.), SHOWING CELLS CONTAINING: (b) BEE BREAD (e) EGG (l) LARVA

bore into wood of several species of trees where they breed. For example, *Archotermopsis wroughtoni* Des. is a borer of conifers in the Himalayas; *Cryptotermes* spp. are drywood termites; *Neotermes militaris* (Des.) is a borer of tea; while *N. gardneri* (Snyder) is a borer of mango and several other species of trees. *N. tectonae* (Damm.), a serious borer of teak in Indonesia, does not occur in India.

### *Defoliators*

The defoliators are mostly beetles (*Coleoptera*), moths and butterflies (*Lepidoptera*). Defoliation is caused by both adults and larvae among beetles and by larvae alone among moths and butterflies. Other defoliating forms are locusts, grasshoppers and crickets (*Orthoptera*), and bees, ants and sawflies (*Hymenoptera*).

Adults and larvae of several species of beetles (*Coleoptera*) of the families *Chrysomelidae, Curculionidae* and *Scarabaeidae* feed on the foliage of trees and sometimes cause serious defoliation. Both larvae and adults of *Calopepla leayana* Latr. (*Chrysomelidae*) are serious pests of *Gmelina arborea* Linn. in eastern India and Burma. The larvae of *Estigmena chinensis* Hope feed on culm sheaths of bamboos, while beetles bore into culms.

Adults of several species of *Curculionidae* either eat flowers, floral buds and leaves or roll up leaves; larvae feed on leaves and also mine them. Beetles of *Myllocerus* spp. defoliate several varieties of trees, while larvae of *Coniatus indicus* Mshll. defoliate *Tamarix gallica* Linn.

Both beetles (Sub-families, *Melolonthinae* and *Rutelinae*) and larvae (Sub-families, *Cetoniinae, Euchirinae* and *Dynastinae*) of family *Scarabaeidae* feed on leaves and cause damage. For example, *Anomala bengalensis* Blanch. and other species of this genus defoliate species of *Cassia* and *Lagerstroemia*; larvae and pupae live in soil. The rhinoceros beetle, *Oryctes rhinoceros* Linn., is a serious pest of coconut palm throughout India; the adults destroy growing buds.

Larvae of some families of *Diptera* either pierce leaves or destroy buds and fruits. *Ophiomyia lantanae* Frog. (*Agromyzidae*) destroys seeds of lantana, while *Asphondylia lantanae* Felt pierces flower buds and causes gall formation.

Sawflies (*Tenthredinidae*) and ants (*Formicidae*, order *Hymenoptera*), damage the foliage of trees. The sawfly, *Cibdela janthina* Klug., defoliates *Rubus* spp. The ants, *Myrmicaria brunnea* Saund. and *Solenopsis geminata* Fabr., bite holes in leaves and buds causing serious damage.

The caterpillar stages of moths and butterflies (*Lepidoptera*) are the principal defoliators among insects. The following are a few of the important species occurring in India:

The deodar defoliator, *Ectropis deodarae* Prout (*Geometridae*), is a serious pest of deodar in western Himalayas; repeated defoliations by the insect kill the trees. The life cycle is annual. The pest is controlled by the use of sticky bands, or bands of insecticidal dusts like BHC, DDT, etc. around tree trunks to prevent the ascent of wingless female moths for oviposition.

The teak defoliator, *Hyblaea puera* Cram. (*Hybla-*

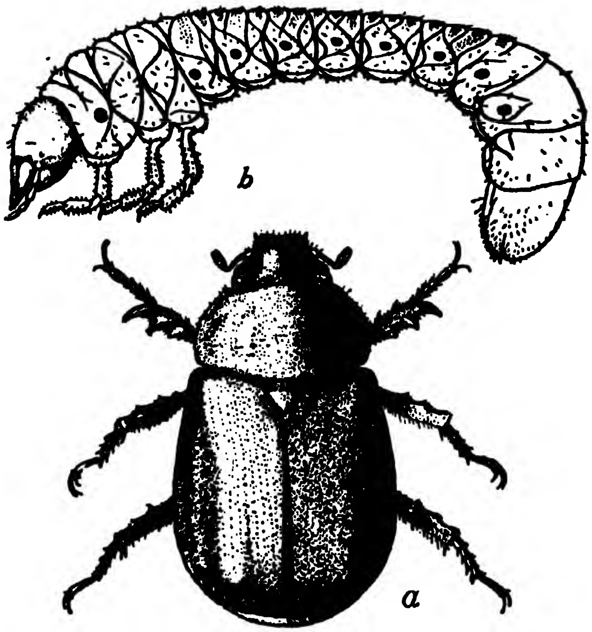



FIG. 123. ANOMALA BENGALENSIS BLANCH.: (a) BEETLE (b) LARVA

*eidae*), is a serious pest of teak. The teak skeletoniser, *Hapalia machaeralis* Wlk. (*Pyralidae*), defoliates teak throughout South-East Asia. Both are multibrooded, there being about 14–15 generations per year in South India.

Owing to their short life cycles and constantly shifting foci of infestation, direct control measures, like spraying forest ground and firing of pupating larvae, are not universally adoptable. Only after an assessment of defective factors in infested localities, polyphagous parasites and predators can be introduced as agents of biological control.

The sal defoliator, *Lymantria mathura* Moore (*Lymantriidae*), occurs periodically and causes extensive defoliation in North India. *L. obfuscata* Wlk. is a pest of willows, *Salix alba* Linn. and *S. fragilis* Linn., in Kashmir. Scraping off or oiling egg masses in winter and spraying kerosene or crude oil on caterpillars and pupae are recommended as control measures.

The shisham defoliator, *Plectoptera reflexa* Guen. (*Noctuidae*), is sometimes a serious pest of shisham in the irrigated parts of the Punjab and Uttar Pradesh.

The bagworm, *Clania cramerii* Westw. (*Psychidae*), is a polyphagous species causing defoliation of acacias, pines and other species of trees throughout India. The female is wingless and grub-like in appearance; it lives in a cylindrical bag made of woven silk covered with thorns, cut pieces of twigs, etc. The life cycle is annual.

Several other families of *Lepidoptera* also include defoliators.

The nymphs and adults of both long-horned and short-horned grasshoppers, locusts and crickets (*Orthoptera*) feed on foliage. Several species of short-horned grasshoppers, such as *Aularches miliaris* Linn., *A. punctatus* Drury and *Hieroglyphus banian* Fabr., cause defoliation in forest nurseries. *Catantops humilis* Serv. and *Ceracris deflorata* Brunn. feed on leaves of teak. *Letana inflata* Brunn. (*Tettigonidae*) feeds on the foliage of sandal, *Santalum album* Linn.

Locusts, which are gregarious, and migratory grasshoppers, also cause serious defoliation. Control is effected by dusting and spraying insecticides, such as BHC and Aldrin.

Among crickets (*Gryllidae*), *Brachytrypes portentosus* Licht. feeds on seedlings of casuarina, teak and other species of trees. *Gymnogryllus humeralis* Wlk. is a pest of casuarina seedlings in Bombay State. To avoid infestation, seed beds in nurseries are isolated by planks or by trenches, and earthenware pot traps are sunk to catch the insects. Water mixed with weak oil emulsion, turpentine or kerosene is also used. Poison baits of sodium fluosilicate and bran mash are sometimes effective.

*Sap-suckers*

The sap-suckers are bugs, aphids, scale insects (*Heteroptera* and *Homoptera*) and thrips (*Thysanoptera*), of which insects of the first three groups are more numerous and also economically more important. Adults and nymphs of the sap-suckers possess proboscides through which they pierce twigs and leaves and suck the sap. Excessive drain of food juices has a deleterious effect on the health of the host plant which may ultimately die.

The whitefly of cotton, *Bemisia gossypiperda* Misra & Lamba, infests several scrubby plants, including the clerodendrons. Control is afforded by spraying with rosin soda or fish oil rosin soap.

*Chermes abietispiceae* Steb. (*Aphididae*) is a pest of conifers, *Picea smithiana* Boiss. and *Abies pindrow* Royle, in the Himalayas. It exhibits alternation of generations between winged and wingless forms. The woolly aphis or American blight, *Eriosoma lanigerum* Hausm., is a serious pest of apple trees. The green peach aphis, *Myzus persicae* (Sulz.), attacks trees like

shisham (*Dalbergia sissoo* Roxb.); it also serves as a vector in transmitting several virus diseases of solanaceous and cruciferous vegetables.

Exposed colonies of aphids are controlled by spraying with soap emulsions and tobacco decoction. Colonies of woolly aphis on branches and stems of apple trees are checked by spraying with fish oil rosin soap and those infesting roots, by fumigation with paradichlorobenzene.

Among scale insects (*Coccidae*), *Aspidiotus destructor* Sign. is a pest of coconut and other palms. The pernicious or San Jose scale, *Quadraspidiotus perniciosus* Comst., is a cosmopolitan pest of willows and several fruit trees, especially in north-western Himalayas. Originally a native of China, it reached India in the year 1911. The pest has been effectively controlled in the Punjab and Kashmir by spraying with oil emulsion containing diesel oil, potash and fish oil soap.

The female of *Dactylopius tomentosus* Linn. (syn. *D. opuntiae* Licht.) breeds freely on some cacti, viz. *Opuntia eliator* Mill. and *O. dillenii* Haw., and kills them; but it does not survive on *O. vulgaris* Mill., *O. ficus-indica* Mill. and *O. decumana* Haw. It has been successfully used for controlling the spreading of cactus species in India. Originally an American insect, it was introduced into Ceylon in 1924 and into India in 1926; in both countries, success has been achieved in controlling the spread of cactus.

*Drosicha mangiferae* Gr. is a serious pest of shisham, *Ficus* spp., mango and other trees, while *D. stebbingi* Gr. is a periodical pest of sal. Application of sticky bands to trunks as barriers and spraying with fish oil rosin soap have been used as checks against *Drosicha* spp. attacking orchids.

The lac insect, *Laccifer* (*Tachardia*) *lacca* (Kerr), is cultivated on a variety of host plants, such as kusum (*Schleichera oleosa* Merrill), palas (*Butea monosperma* Kuntze) and ber (*Zizyphus jujuba* Lam.). Certain plants are preferred to others naturally and the quality of the lac produced varies with the host. When infestation is heavy, the host plant suffers in vitality and may even die. Insect enemies, like *Eublemma amabilis* Moore (*Noctuidae*) and *Holcocera pulverea* Meyr. (*Blastofascidae*), attack the lac insect and damage lac crops.

The canefly, *Eurybrachys tomentosa* Fabr. (*Fulgoridae*), feeds on *Albizzia lebbek* Benth., *Cassia fistula* Linn., *Santalum album* Linn. and other species of trees, and retards their growth. No control measures have so far been devised.

Among leaf hoppers or green flies (*Jassidae*), *Idiocerus atkinsoni* Leth. and other species of the genus are pests of mango and frequently cause heavy loss to the crop. *Jassus indicus* Wlk. is suspected to transmit the virus causing the spike disease of sandal. Specific control measures have not been known, but pests of agricultural and fruit crops can be controlled by spraying with DDT.

Stink bugs (*Pentatomidae*) are relatively large in size (length, 5–15 cm.). The champ bug, *Urostylis punctigera* Westw., is frequently a serious pest of champaka (*Michelia champaca* Linn.) in Bengal and Assam. It has five generations in a year: nymphs and adults feed on leaf and shoot sap. Pure stands are more susceptible to attack than mixed ones. Insecticidal sprays, such as lime-sulphur wash and DDT, afford control against the pest.

Jumping plant lice (*Psyllidae*) feed on leaves of trees and cause gall formation. Heavy attacks may either dwarf the growth of trees or even kill them. The following are the more important pest species: *Apsylla cistellata* Buckt. on mango; *Euphalerus vittatus* Crawf. on *Cassia fistula* Linn.; *Phyllopleeta hirsuta* Crawf. on *Terminalia tomentosa* Wight & Arn.; and *Trioza fletcheri* Crawf. on *Gmelina arborea* Linn.

The lantana lace bug, *Teleonemia scrupulosa* Stal (syn. *T. lantanae* Dist., *Tingidae* or *Tingitidae*), breeds principally on *Lantana* spp., but in the absence of this plant, it has a tendency to attack teak and other plants. It was originally introduced in Dehra Dun (U.P.) in 1941 from Australia with the object of its acclimatization and use for controlling the spread of lantana, which was a serious plant pest in many parts of India. It was bred under quarantine conditions for a few years, but the trial was abandoned in 1943 due to the possible danger to teak on which it may get established in the absence of lantana. It has, however, become established in Dehra Dun and its vicinity.

Thrips (*Thysanoptera*) are tiny, soft-bodied insects commonly feeding on saps of flowers, buds, leaves and soft shoots. Infestation leads to the premature dropping of flowers; leaves and buds shrivel up and die. A few species are serious pests of trees. *Androthrips dhumrapaksha* Ayyar causes considerable damage to the tender foliage of *Ficus retusa* Linn. in South India. The grape vine thrips, *Rhipiphorothrips cruentatus* Hood, occurs on several trees, e.g. *Anacardium occidentale* Linn. and *Syzygium cumini* Skeels, and causes considerable damage. It has 5–8

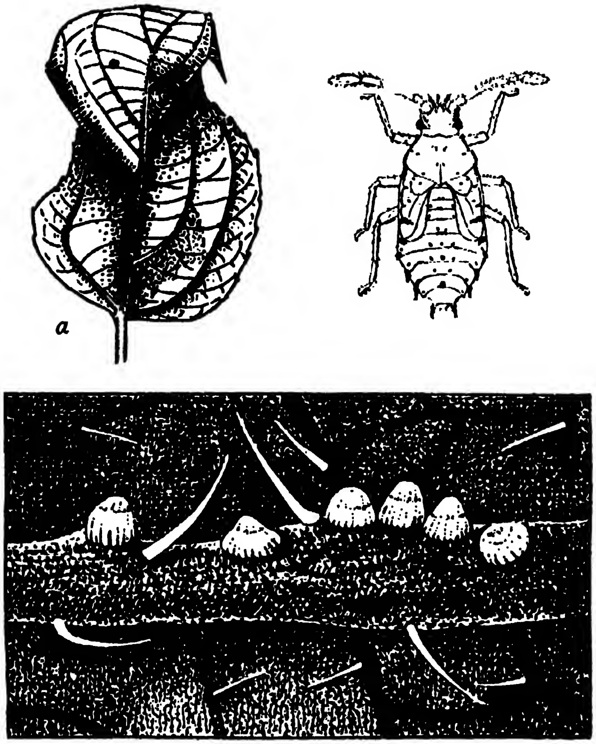


FIG. 124. EGG-LAYING OF LANTANA BUG (TELEONEMIA SCRUPULOSA STAL) ON LEAVES OF LANTANA: (a) UNDERSIDE OF LEAF SHOWING CURLING AND CRINKLING AS A RESULT OF EGG-LAYING (b) FIFTH STAGE NYMPH OF THE SAME (c) PORTION OF LOWER SURFACE OF LANTANA LEAF SHOWING EGGS LAID ALONG MIDRIB

generations a year. *Taeniothrips cardamomi* Ayyar attacks buds and blossoms of cardamom, *Elettaria Cardamomum* Maton, causing serious loss of crop; at one time it even threatened the existence of cardamon plantations in South India. The pest is controlled by spraying tobacco extracts; decoctions of leaves of *Calotropis procera* R. Br. and *Azadirachta indica* A. Juss. with soap are useful substitutes.

*Other Pests*

The insects considered under this group include some members of the orders *Diptera, Hymenoptera* and *Isoptera*. They destroy one part or the other of trees which they infest; a few are indirectly harmful and some are beneficial to trees. Blood-sucking *Diptera* cause annoyance to human beings and animals in forests and transmit diseases. Some *Diptera* and *Hymenoptera* parasitise insect pests in egg, larval or other stages and thus play an important role in pest control.

The itonidid gall midges (Order *Diptera*, family *Cecidomyidae*) are known to produce galls. Flies belonging to *Tachinidae* parasitise several insect pests of trees; eggs (larvae in the case of viviparous species) are laid on leaves or in the host insect.

The gall wasps (Order *Hymenoptera*, family *Cynipidae*) cause leaf galls. Several families are parasitic on other insects, including pests of trees, and are useful for the biological control of pests; the parasites are bred in the laboratory and released at the site of the epidemic. The more important parasitic families are the following:

Braconid wasps (*Braconidae*) lay eggs either on or inside the host caterpillar and larvae feed either externally as ectoparasites or internally as endoparasites. *Apanteles machaeralis* Wlksn. is an endoparasite of the teak skeletoniser, *Hapalia machaeralis* Wlk.: *Cedria paradoxa* Wlksn. normally parasitises the pyralid host, *Margaronia pyloalis* Wlk., but can be bred on several other pyralids including the teak skeletoniser for the control of which it can be adopted.

Both eggs and larvae of the chalcid wasps (*Chalcididae*) are endoparasitic. *Brachymeria hearseyi* Kirb. parasitises the pupae of toon and mahogany shoot borer, *Hypsipyla robusta* Moore. *B. tachardiae* Cam. parasitises the pupae of certain moths, including several pests of trees.

Ichneumon wasps (*Ichneumonidae*) are mostly useful as parasites. The mode of oviposition and parasitisation is similar to that in *Braconidae*. *Dioctes argenteopilosa* Cam. parasitises the caterpillars of the teak skeletoniser and several other moths. *Rhyssa persuasoria himalayensis* Riley parasitises the wood wasp, *Sirex imperialis* Kirb., in the Himalayas.

*Trichogramma evanescens minutum* Riley (Family *Trichogrammatidae*) is an egg parasite widely used for the control of sugarcane borers, cotton bollworms, teak defoliators and pests of tea and lac. *Trichogrammatoidea nana* Zehn. is an egg parasite of moths of *Noctuidae, Pyralidae* and *Tineidae*.

Other families of parasitic *Hymenoptera* are: *Bethylidae, Elasmidae, Encyrtidae, Eulophidae, Microgasteridae, Perilampidae, Pteromalidae* and *Scelidonidae*.

Some termites (*Isoptera*) are pests of living trees: others attack dead or dying trees and seedlings in nurseries; many destroy decaying wood matter and serve a useful role in building up soil and humus in forests. As dry wood pests they are a serious menace to stored timber in depots, furniture and fittings, books and other cellulosic material.

*Cryptotermes domesticus* Holmg. (*Kalotermitidae*) is a common pest of dry wood in houses. Several species of the genus *Clyptotermes* nest in living trees, such as casuarina and toon.

*Coptotermes heimi* (Was.) (*Rhinotermitidae*) commonly attacks woodwork in dwellings. *C. ceylonicus* Holmg. infests living tea and rubber plants in South India and Ceylon, while an allied species, *C. curvignathus* Holmg., is a serious pest of rubber plant in Malaya and Indonesia. *Heterotermes indicola* (Was.) attacks woodwork in dwellings.

The common mound-building termites in India are: *Odontotermes* (*Cyclotermes*) *obesus* Ramb. in North India and *O.* (*Cyclotermes*) *redemanni* (Was.) in East and South India; they are not serious pests of trees. *O. feae* (Was.) is a large species which commonly attacks timber in buildings. *O. parvidens* Holmg. & Holmg., though usually not a serious pest, has recently been reported to attack teak trees, causing death by eating away the bark and the cambium.

Protective measures against termites are varied. Nests and colonies are destroyed. Wooden boards used at the edges of seed beds are creosoted to prevent the approach of termites. Oil cakes of castor, karanja (*Pongamia* sp.), mohwa (*Madhuka* sp.) and neem, which are of manurial value, have a limited deterrent effect on termites. Prompt transplanting of nursery seedlings in fields prevents termite attack of roots and rootlets. Stumps and root-pruned transplants may be dipped in 5% lead arsenate solution or an aqueous mixture containing 2% Paris green and 4% lime. Sowing on ash beds is recommended and nursery beds are watered in the dry season with a weak emulsion containing crude oil or fish oil, or a weak decoction of tobacco; in the wet season, when the soil is moist, beds are dusted with dry soil or sand or ashes mixed with small quantities of Paris green or white arsenic; slow-acting fumigants, like *p*- or *o*-dichlorobenzene, may also be used as detergents to termites. Repeated digging and turning of soil at short intervals are preferred. Red ants also destroy termites. Transplanted stumps and cuttings may be protected against termites by watering with weak crude oil emulsion, sodium arsenite solution or lead arsenite solution.

Paris green is effective in the control of termites (*Kalotermitidae*) affecting wood; it may be blown into a hole drilled into the wood and the hole sealed. Direct protective methods are resorted to in the case of termites attacking plantations, isolated trees, and roadside and garden avenues. Protection of trees against termites which attack the bark is obtained by the application, at the base, of protective bands charged with lead arsenate. Regulation of overhead shade and thinning to prevent excessive growth also help in checking the attack .

In the case of stored timbers, the floors of depots and yards should be kept dry and timber should be stacked on concrete supports, brick work, stone or iron rails, or creosoted wooden framework. Adequate air circulation is essential. Only creosoted or otherwise treated timber can be left in contact with the ground. Wooden poles and posts treated with high-boiling coal tar creosote can withstand termite attack for 50–60 years, provided a minimum absorption of 10 lb. of creosote plus 5 lb. of fuel oil per cu. ft. of wood is ensured. Surface charring is not always effective as a protection against termites.

### PESTS OF STORED AGRICULTURAL PRODUCTS

It has been computed that losses due to infestation of stored produce amount roughly to about 10% of the total value of the harvested produce. Effective measures are necessary not only to check the access of pests to stored grains, but also to treat infested grains and prevent further loss.

The pests of stored grains are usually beetles (*Coleoptera*) and moths (*Lepidoptera*). The former cause damage both as adults and larvae, while moths feed only in their caterpillar stage.

One of the most serious pests of grain is the rice weevil, *Sitophilus oryzae* Linn., which attacks rice, wheat, maize, jowar, etc. A single grub can hollow out a whole grain and as there are five generations in a year in warm countries, the damage caused is enormous. Another beetle pest is the khapra beetle, *Trogoderma granarium* Everts, the grub of which attacks the embryo of the grain. The lesser grain borer, *Rhizopertha dominica* Fabr., attacks almost all grains and even dried potato; it is particularly destructive under moist conditions. Among the other beetle pests, mention may be made of the rust-red flour beetle, *Tribolium castaneum* (Herbst.), *T. confusum* (Duv.), *Oryzaephilus surinamensis* Linn., *Latheticus oryzae* Waterh. and *Laemophloeus minutus* Oliv., which attack damaged grains and flour and cause much loss.

The pulse beetles infest almost all pulse grains. *Bruchus chinensis* Linn. and *B. analis* Fabr. damage red gram, gram, horse gram, pea, cow pea, etc., while *Bruchus phaseoli* Gyll. is a pest of field bean (*Dolichos lablab* Linn.) both in the field and in the store.

*Callosobruchus maculatus* Fabr. is a pest of cow pea. The tamarind seed beetle, *Pachymerus gonagra* Fabr., breeds on stored tamarind seed.

Among the miscellaneous pests of stored produce, the drug store beetle, *Stegobium paniceum* Linn., attacks coriander, cumin seed and dried turmeric in stores, while the cigarette beetle, *Lasioderma serricorne* Fabr., is a specific pest of tobacco products, dry chillies, pepper, dried ginger, ganja and opium cakes. The copra beetle, *Necrobia rufipes* deG., attacks fish manure, copra, oilseed cakes and cured meat.

The Angoumois grain moth, *Sitotroga cerealella* Oliv., is a pest of stored paddy, wheat and jowar and wheat flour. The rice moth, *Corcyra cephalonica* Staint., infests stored rice and other cereals, broken pulses and groundnut seed, and lives under cover in galleries. The Indian meal moth, *Plodia interpunctella* Hübn., also lives in galleries among cereals, nuts, dried fruits and broken cashewnuts. The almond moth, *Ephestia cautella* Wlk., has similar habits and attacks dry fruits, groundnut cake and oilseeds. An allied species, *E. elutella* Hübn., is a serious pest of stored tobacco leaf in America and in the Mediterranean area, but so far it has not been recorded in India; its entry is sought to be prevented by the enforcement of quarantine legislation.

Harvested groundnut pods and til plants heaped on threshing yards are liable to infestation by a lygaeid bug, *Aphanus sordidus* Fabr. A scale insect, *Aspidiotus hartii* Ckll., breeds in stored rhizomes of turmeric. A tingid bug, *Recaredus rex* Dist., and a mealy bug, *Pseudococcus corymbatus* Gr., are often found breeding in potato tubers under storage. The most serious pest of potato tubers in storage, however, is the potato moth, *Gnorimoschema operculella* Zell. White ants often attack jute bag containers of grain in stores.

Perfect cleanliness of grain or other agriculture produce is an essential requirement for the control of pests. The grains should be thoroughly dried in the sun and as far as possible dry conditions must be maintained in storage godowns. The containers must be clean and completely closed up. Storage rooms must be well ventilated and cleaned. In case of infestation developing, fumigation is necessary.

### INSECT VECTORS OF PLANT VIRUSES

Viruses are pathogens or disease-producing agents much smaller in size (200μ or less) than the minutest bacteria. They are known and understood by reference to their hosts or the symptoms they produce, such as tobacco, potato, tomato, bean, sugarcane and other *mosaics*; peach, aster and other *yellows*; *curly top* of sugar beet; *spotted wilt* of tomato; *swollen shoot* of cacao; *streak* of maize; and *club leaf* of clover. They are the causative agents of smallpox, measles, mumps, influenza and rabies in man, and distemper, swine-fever and foot-and-mouth disease in animals. Viruses are not inactivated by pesticidal chemicals, but some are affected by alcohol and other chemicals and by heat.

In nature, the major mode of transmission of plant viruses from an infected to a healthy host is undoubtedly through insect vectors. The vectors for all viruses are not known, but most of the known vectors belong to the order *Homoptera*, e.g. plant lice or aphids (*Aphididae*), leaf hoppers (*Jassidae*), white flies (*Aleurodidae*), frog hoppers (*Coreopidae*) and mealy bugs (*Coccidae*); aphids act as vectors of the mosaic group of viruses; leaf hoppers transmit the yellow group of viruses. Insect vectors belonging to other orders are: thrips (*Thysanoptera*), grasshoppers (*Orthoptera*), beetles (*Coleoptera*) and earwigs (*Dermaptera*).

The number of viruses transmitted by insects with biting or chewing mouth parts is small and includes squash mosaic, cow pea mosaic and turnip yellow mosaic. Experimentally, the dodder group of parasitic flowering plants has been used to conserve and transmit viruses because of their habit of living in organic union with their host plants, into the stems and leaves of which they send haustoria.

Some insect vectors may transmit several viruses, while some viruses may be transmitted by several insect vectors. The aphid, *Myzus persicae* (Sulz.), is known to transmit 25 different viruses, while aster yellows and onion yellow dwarf viruses have been shown to be transmitted by 22 species of leaf hoppers and 50 species of aphids respectively. Some viruses, like maize streak and Fiji disease of sugarcane, are each transmitted by only one insect species, while some insect vectors, such as the Colorado beetle, *Leptinotarsa decemlineata* (Say), and the jassid, *Empoasca devastans* Dist., can each transmit only one virus. It also happens that an insect may transmit one strain of a virus, but not another of the same virus.

Although mechanical transmission of viruses by insects, birds and other agencies alighting on infected plants and thence moving on to healthy plants, may occur, an insect must feed upon a virus-infected plant

before it can function as a vector. Some virus infections may be picked up quickly by appropriate vectors, but some others can be acquired only by prolonged feeding. Infections which are picked up quickly are usually also lost quickly, but those, which are acquired after prolonged feeding, persist in the vector for long periods. The sugar beet mosaic virus is picked up and transmitted by its aphid vector, *Aphis rumicis* Linn., in about ten minutes of feeding on diseased plants, but the capacity to transmit the virus is also lost if the aphid feeds on healthy plants a few times. On the other hand, the aphid, *Myzus persicae* (Sulz.), is able to transmit the potato leaf roll virus only after a lapse of at least 24 hours after feeding. It appears that sometimes it is the virus that determines how quickly a vector would become infective and how long it would remain so; and sometimes it is the vector that plays the determining role. While some viruses require an incubation period, to undergo some transformation or merely to multiply in the body of the insect vector, to enable the vector to become infective, others do not. There is good evidence for the multiplication of infection in the body of the vector but there is not much evidence for transformation, except in the direction of greater virulence, which may itself be the result of multiplication. Aster yellows and clover club leaf viruses are known to multiply in the body of their insect vectors. It has been stated in the case of tobacco mosaic virus that the fact that tobacco mosaic virus is infective at dilutions of 1 : 1,000,000 and that the juice from the inoculated plants can again be diluted to the same degree shows that there has been approximately a million-fold multiplication.

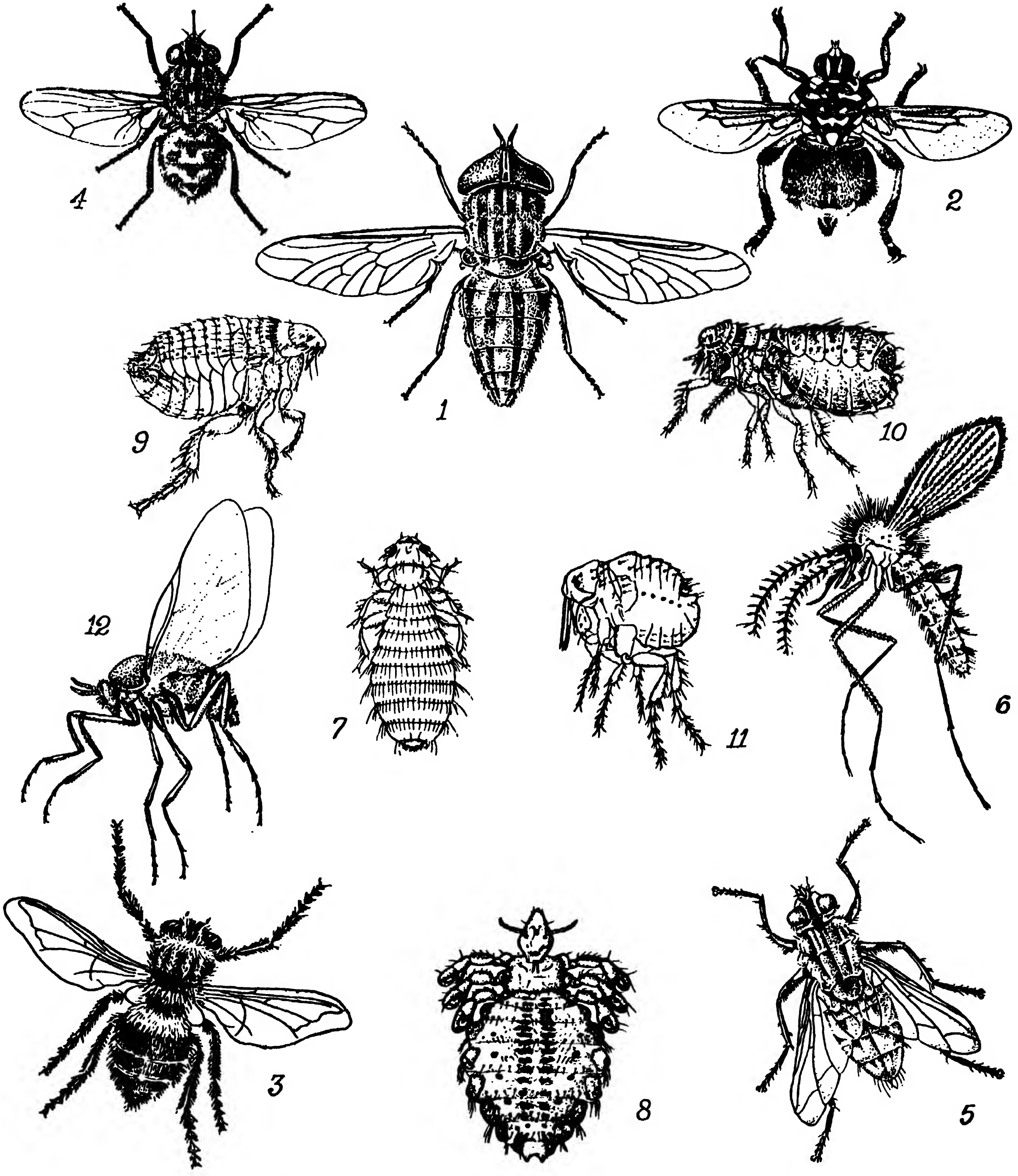
While most vectors of plant viruses are sucking insects, all sucking insects are by no means vectors. Apart from the fact that closely allied species of sucking insects, even belonging to the same genus, may not necessarily transmit the same virus, there may be strains or races in an insect species which may be incapable of transmitting a virus from an infected host plant, even though they may feed upon it, as happens in the case of the jassid, *Cicadulina mbila* (Naude), the vector of the maize streak disease : some races of this jassid have been bred which can pick up the virus but cannot normally transmit it. While viruses are picked up by most insect vectors in their adult stage, the spotted wilt virus of tomato can be first acquired only by the larvae of the thrips which transmit it, the adult becoming infective only if it has grown out of an infective larva. Congenital transmission of some viruses from one generation of its insect vector to another is also known as in the case of the leaf hopper, *Agalliopsis novella* Say, in which the clover club leaf virus was passed through 21 generations over a period of five years without further recourse to a source of virus, the original virus-bearing female being mated to a virus-free male five years previously. The virus infection in the case of the jassids, *Nephotettix apicalis* var. *cincticeps* Uhl and *Deltocephalus dorsalis* Motsch., which are the vectors of the rice dwarf virus, can pass through the eggs of the infective female insect so that the emerging nymphs are viruliferous.

There is no visible difference between an insect which has acquired a virus infection and another insect of the same species and age which has not. It has been shown that the 'inactive' races of *C. mbila* can become 'active' if the intestine of the insect is punctured with a sterilised needle, thereby allowing the virus, already acquired, to travel into the blood stream. This has led to the presumption that the lining cells of the intestine in the 'inactive' insect resist the passage of the virus, while those in the 'active' insect do not. Finally it may be noted that the relationship between a virus and its insect vector and the processes and the conditions under which the latter picks up and transmits the virus are highly complex and our knowledge of the subject is far from complete.

#### PESTS OF CATTLE AND OTHER DOMESTIC ANIMALS

Cattle and other domestic animals like sheep, horses and poultry are subject to the attacks of various insect pests, which not only cause direct injury and annoyance to the animal hosts they attack, but are also responsible for causing diseases and functional troubles in them. The more important pests of domestic animals, e.g. horseflies, botflies, biting flies, flesh maggots, fleas, lice and bird lice, belong to certain groups of insects particularly adapted for a parasitic life on warm blooded animals. Cattle grazing in forest areas are often subject to attacks of bees, wasps, blister beetles and spiny and hairy caterpillars.

Insect pests cause loss of condition in milch and work cattle with serious economic implications. In an agricultural country like India, where over 60% of the national income is dependent on the cattle industry and other allied pursuits, the well being of livestock is a matter of utmost importance. Considerable mortality among cattle and other livestock is




PESTS OF CATTLE AND OTHER DOMESTIC ANIMALS

**1. Grey gadfly** (*Tabanus striatus*) (×3) **2. Lousefly** (*Hippobosca maculata*) (×4) **3. Ox bot or warblefly** (*Hypoderma lineatum*) (×3) **4. Stablefly** (*Stomoxys calcitrans*) (×4) **5. Fleshfly** (*Sarcophaga lineaticollis*) (×2½) **6. Sandfly** (*Phlebotomus argentipes*), **female** (×15) **7. Fowl louse** (*Menopon pallidum*) (×18) **8. Cattle louse** (*Haematopinus tuberculatus*) (×14) **9. Cat flea** (*Ctenocephalus felis*) (×7) **10. Dog flea** (*Ctenocephalus canis*) (×14) **11. Hen flea** (*Echidnophaga gallinaceus*) (×24) **12. Blackfly** (*Simulium* **sp.**) (×10)

due to diseases of viral, bacterial, protozoal and helminthic origin. In live animals, insect pests inflict a variety of suffering, such as defective growth, decrease of vigour, low capacity for reproduction, less production of milk, meat, egg and wool and less work. Affected animals are susceptible to many infectious diseases. Hides and skins of dead or slaughtered animals damaged by warbleflies, ticks, etc. fetch much lower prices.

Among the fly pests (*Diptera*) of cattle, the gadflies (*Tabanidae*), louseflies (*Hippoboscidae*), botflies (*Oestridae*), flesh maggots (*Sarcophagidae*), biting flies (*Muscidae*) and mosquitoes (*Culicidae*) are important. Some are pests only in the adult stage, while others only in the larval or maggot stages. Insect pests, such as mosquitoes, sandflies, blackflies, lice and fleas, are pests common to domestic animals and human beings.

Gadflies (Family *Tabanidae*) are strongly built active flies ; the males possess large eyes and feed on the nectar of flowers, whereas the females are parasitic on cattle and at times also attack man. Eggs are usually attached to aquatic plants in masses of 100 or more, and the larvae develop in moist soil. The commonest forms are the greyfly, *Tabanus striatus* Fabr., and the banded winged species, *Chrysops dispar* Fabr., generally found hovering about cattle yards, stables and grazing grounds. They frequently visit the host and suck blood. The horsefly, *Tabanus rubidus* Wied., is reported to transmit surra disease in horses, mules, cattle and camels. In forests and hills, *Haematopota* and *Corizoneura* spp. are reported to be serious pests. The hairy forms with remarkably long and pointed proboscides, as in *Corizoneura taprobanes* Wlk., are parasitic on wild animals. *Haematopota montana* Ricardo is known to attack man. Destruction of egg masses and spraying of fly-repellent mixtures have proved effective as control measures.

Louseflies (Family *Hippoboscidae*) are leathery, flattened forms, with wings and strong claws on legs which enable them to remain clinging to the skins of host animals. Adult flies suck blood. The female insect deposits fairly mature larvae, instead of eggs, and they change into short roundish pupae from which the flies emerge. The common species that attack cattle, dogs and horses are *Hippobosca maculata* Leach and *H. capensis* Olf. A degenerate wingless fly, the sheep tick, *Melophagus ovinus* (Linn.), is known to attack sheep in different parts of India. Preventive measures, like avoiding over-irrigation, oiling of stagnant pools, keeping the animals in stables during the day and covering them with protective blankets or nets in the night or spraying them with fly-repellent mixtures, help to check the spread and attack of the pests. Dipping or spraying sheep with powders or emulsifiable formulations of DDT and Chlordane is effective.

Botflies (Family *Oestridae*) are sombre coloured flies with heavy body, large head and rudimentary mouth parts. Their life histories are admirably adapted to their peculiar parasitic habits. In India, the horse botfly, *Gasterophilus intestinalis* (*equi*) deG., the sheep bot, *Oestrus ovis* Linn., and the ox bot or warblefly, *Hypoderma lineatum* De Vill., are serious pests.

The larvae of the horse botfly feed on mucus secretions and cause digestive troubles in the host. *G. intestinalis* deG. is common in North India. Regular and thorough grooming to remove eggs from hair helps to check infestation and improve the general health of the animal.

The larvae of sheep bot, which hatch out from the eggs laid in the nasal chambers of sheep, make their way into other chambers of the head, causing great annoyance and trouble to the host. Considerable damage to wool has also been recorded. The maggots either crawl out or are expelled as a result of sneezing with mucus discharge and pupate in the soil. Darkened shelters for sheep during the months when flies are active afford protection from infestation. Application of pine tar in the nostrils prevents larvae from attachment ; injection of one fluid ounce of 3% saponified cresol into each nostril is reported to provide an effective control measure against maggots which have become established.

The eggs of the warblefly, common in North India, attach themselves to the body of the host, and young larvae, hatching out, develop into fleshy maggots which cause a characteristic swelling with inflammation on the skin of the host : the larvae pierce through and come out when they are ready for pupation. Oxen, goats and cows attacked by warbleflies readily lose condition and become unhealthy. Milk production is considerably reduced. Warbled hides do not command good prices. Other animals, like camel, buffalo, deer, rhinoceros and even elephant, are occasionally attacked by the warblefly. The elephant bot, *Cobboldia elephantis* Steel, has been recorded from Anamalai hills in South India. Dusting tumours with derris soap, washing with tobacco-lime, and keeping hairs on legs clean

and dry during the egg-laying season of the fly, help to a great extent in checking the pest.

Blue-bottle (Family *Calliphoridae*) are common flies of blue or green hue, whose larvae are found on exposed flesh, wounds and sores of cattle. During heavy infestation the maggots cause cutaneous diseases. Sometimes, exposed or neglected wounds in man are also infested. A common blue-bottle fly with red cheeks, *Pycnosoma flaviceps* Macq., usually found on night soil or in the vicinity of slaugher houses, is closely allied to the green-bottle fly. *Lucilia argyrocephala* Macq. (syn. *L. serenissima* Wlk.), a common South Indian form. This fly infests cattle, lays eggs in wool soiled by urine and dung, and the maggots invade healthy tissues and cause inflammation. Proper care of animals, dehorning, and application of saturated E.Q.335 emulsion to affected areas afford checks against the fly attack.

The fleshfly, *Sarcophaga lineaticollis* Macq. (Family *Sarcophagidae*), common in South India, is also found with blue-bottles and is closely allied to the housefly in general appearance and size, but differs from the latter in possessing mouth parts adapted to piercing the skin and sucking the blood. It is commonly found in stables and cow sheds, and is widely distributed. The stablefly, *Stomoxys calcitrans* Linn. (Family *Muscidae*), with a distinctly pointed piercing proboscis, is parasitic on horses, mules, camels and other domestic animals, and is reported to transmit diseases like surra and rinderpest. The milk yield of affected animals is considerably reduced and animals become weak and drowsy: they find it difficult to stay on their feet. The fly passes through its early stages in manure dumps and moist situations. Other flies commonly found along with stablefly and recorded as pests are *Lyperosia exigua* Mej. and *Philaematomyia crassirostris* (Stein) (*P. insignis* Austen), both belonging to the family *Muscidae*. Keeping horses in screened stables at night and spraying fly-repellent mixtures containing DDT or BHC are effective in controlling the flies.

Mosquitoes (Family *Culicidae*) of different kinds are among the recorded pests of cattle. *Culex fatigans* Wied. (Hindi—*Machhar*; Beng.—*Mosha*) sucks the blood of almost all animals and is responsible for the transmission of malaria in birds. *Aedes* (*Stegomyia*) *aegypti* Linn. transmits fowl malaria and fowl pox: it causes encephalomyelitis in horses. Mosquitoes can be controlled by eradicating larvae and pupae in their breeding places by the application of crude oil and Paris green and by destroying adults with DDT spray.

Sandflies (*Phlebotomus papatasii* Scop. and *P. argentipes* Ann. & Brun.) (Family *Psychodidae*) suck blood of all animals; as such they are a nuisance. They are not known to be vectors of any diseases of animals.

Blackflies (*Simulium indicum* Bech., family *Simuliidae*) are blood-sucking insects, known to transmit onchocerciasis of cattle and leucocytozoon of poultry. As control measures, breeding places in running streams should be kept free from debris; spraying of DDT is effective.

Bird lice (Order *Mallophaga*) are non-blood-sucking wingless insects with mouth parts adapted for cutting, biting and scratching skin, feathers and body scales of birds, on which they remain as pests. They have a hard and horny body, somewhat flattened, and are found clinging to hairs and feathers of the host. A few species have also been recorded as attacking mammals, like sheep, dogs and horses. The life cycle of the parasite is usually spent on the host animal. The common fowl louse, *Menopon pallidum* Nitz., is widely distributed; it infests birds and causes loss of condition. Dusting of sodium fluoride or DDT affords effective protection against bird lice.

Blood-sucking lice and fleas (Orders *Anoplura* and *Siphonaptera*) affect not only cattle and other mammals like dog, hog, pig and camel, but also man. The cattle louse, *Haematopinus tuberculatus* Nitz. & Gieb., is commonly found inside ear lobes and other unprotected parts of buffaloes and oxen, and is known to transmit the surra diseases of cattle. The pig louse, *H. suis* Linn., is parasitic on pigs and the ox louse, *Linognathus vituli* (Linn.), sucks the blood of cattle. The sheep ked, *Bovicola ovis* (Linn.), which is parasitic on sheep, causes serious damage to wool. Spraying the animal with DDT mixtures and dusting or dipping in arsenical solutions provide protection against these lice.

Fleas (Order *Siphonaptera*) are small wingless insects with laterally compressed, hairy bodies and stout hind legs adapted for leaping; mouth parts are suited for piercing and sucking blood from warm-blooded animals. The rat flea, *Xenopsylla cheopis* Roth. (Family *Pulicidae*), is parasitic on rat and transmits bubonic plague from rat to man. The cat flea, *Ctenocephalus felis* Bouche, and the dog flea, *C. canis* Curt., which are parasitic on cats, dogs and cattle, are responsible for causing haemorrhagic septicaemia and anthrax diseases. The dog flea serves also as a larval host for the common dog tape worm. The hen flea, *Echidnophaga gallinaceus* Westw

(Family *Sarcopsyllidae*), parasitises fowls, especially on the heads; it sometimes attacks man also. For the control of fleas, the sources of infestation, namely cats, dogs and other animals should be kept clean and properly cared for. Infested rats should be destroyed. Periodical dusting of carpets, matting, etc., and thorough washing of flea-haunted rooms with sanitary fluids effectively check their spread and multiplication. Use of flake naphthalene and strong tar soap and spraying of DDT, creosote oil or kerosene oil are also helpful in checking fleas.

### PESTS OF HUMAN BEINGS

Insect pests of human beings are reported to be directly or indirectly responsible for about half the number of deaths in India. According to the statistics for 1950, the deaths due to malaria and other fevers were 53.55%, while deaths due to cholera, plague, dysentery and respiratory causes were 14%. Malaria alone was, till recently, responsible for about one million deaths every year; it is now on the verge of being stamped out. Advances in public health measures have demonstrated that this colossal loss of human life is preventible.

The pests may be grouped into household and outdoor nuisance pests and pests which are responsible for the mechanical transmission of communicable diseases.

#### *Household Nuisance Pests*

Silverfish (Order *Thysanura*, family *Lepismatidae*) are small wingless insects with their mouth parts better suited for scraping than for chewing; they move with great rapidity and thrive best in dark, moist places, shunning light and dry and well-ventilated places. They feed on carbohydrates, such as starch and dextrin, and also on substances containing protein, such as glue, gum, etc. and sometimes cause great damage to glazed paper, books and photographs. They may also damage fabrics of cotton, linen and artificial silk. *Lepisma saccharina* Linn., which occurs in India, is about 1/3 inch long, with the body tapering from head to tail and clothed with glistening silvery scales. The female lays eggs in crevices and other concealed places, which hatch into tiny young ones, resembling the parent except in size and attaining maturity in about 9 months.

Cleanliness and good ventilation of the house keep the pest in check; 5% DDT solution or emulsion or 10% DDT dust applied in book cases and on clothing, respectively, will effectively control silverfish. 20% Chlordane is also a highly effective poison for them.

Cockroaches (Order *Blattaria*, family *Blattidae*, e.g. *Periplaneta americana* Linn., *P. australasiae* Fabr. and *Blatella germanica* Linn.) are probably the most common household pests in the world. They prefer warm dark corners in godowns, kitchens, bathrooms, crevices in furniture and other wood work. They are rarely seen during the day, except when disturbed, and are generally dark brown in colour and variable in size. They emit a distinctive odour and infestation is often revealed by this odour on food, crockery and other utensils over which they have walked. The eggs are laid encased in a horny capsule and nymphs, hatching out of them, closely resemble the adults. After a succession of moults, the adult cockroaches, sexually mature, emerge.

Cockroaches are omnivorous and feed on every type of food for human consumption. In addition to draining food supplies, they act as potential vectors of diseases because of their loathsome habit of crawling on filth and foodstuffs alike. Scrupulous cleanliness and general tidying up of nooks and crevices in furniture help to keep down the roach population. Chlordane 2% emulsion or 5% dust applied into cracks and other hiding places usually remains effective for several weeks. 5–10% DDT dust also gives satisfactory control. 3% Malathion solution or emulsion is effective against resistant roaches but its effect is less persistent.

Two species of crickets (Order *Orthoptera*, family *Gryllidae*), viz. *Acheta* (*Gryllulus*) *domestica* Linn. and *Gryllodes* (*Gryllulus*) *sigillatus* Wlk., are common in India; the former, known as the European house cricket, is also capable of damaging cultivated crops; the latter is chiefly a household species. They are omnivorous, but especially attack woollen and artificial silk fabrics, damaging them rather badly. They also like starchy food, such as bread, cakes, biscuits, etc. During the day they remain hidden in cracks and crevices, behind hanging clothes, wall-papers and pictures, and thrive best in damp and warm places. They are specially active during the rainy season.

The female lays eggs in clusters; the nymphs hatching out are similar in general shape to adults. They reach maturity in about 3 months. Both adults and the young do damage.

Liberal sprinkling of naphthalene balls in trunks and wardrobes saves clothes from their attack.

Chlordane applied as 2% spray or 5% dust keeps them under control.

Book lice (Order *Corrodentia* - e.g. *Liposcellis transvallensis* End.) or psocids are tiny, soft-bodied, pale yellow or greyish white, wingless insects less than 1/12 inch in length. They are called book lice because they are frequently found among pages of old books and are louse-like in appearance. They feed on tiny moulds which are often found in damp, undisturbed places, on old books and insect collections, which psocids are apt to destroy. They prefer dark and damp places and are usually plentiful in old, damp, mouldy volumes of books lying undisturbed in dark, dirty corners of rooms and libraries. Little is known about the life-history; the female lays white, oval, microscopic eggs; the young that hatch out are similar to adults in appearance.

Thorough house cleaning, sunning, airing and drying of rooms and books keep the pest in check; fumigation and incorporation of poisons in the binding paste or on covers and backs of books keep them free from psocids. Residual sprays, such as oil base 2% Chlordane or 5% DDT, are very useful.

Termites or white ants (Order *Isoptera*, family *Rhinotermitidae*) are ant-like in appearance and like ants live in large colonies made up of different castes, namely workers, soldiers and reproductive forms. The workers and soldiers are wingless. The damage is caused solely by workers. *Coptotermes ceylonicus* Holmg., *C. heimi* (Was.) and *Heterotermes indicola* (Was.) are the main species which cause damage to wood work, furniture, books and other household effects in buildings. They form their nests underground and in logs or fairly damp wood work of buildings. When fully established, it is difficult to eradicate these insects. The first step at their control should be to break contact between their nests and the wood work in buildings by destroying the shelter tubes through which workers move to and fro. Application of DDT, BHC or Aldrin, in the form of spray or dust, into their underground nests helps to control the termites, but complete control is possible only if the 'Queen' is destroyed either by the conveyance of insecticide particles by workers or soldiers to the queen or by the workers feeding the reproductive forms with poisoned food or by the destruction of their food reserves.

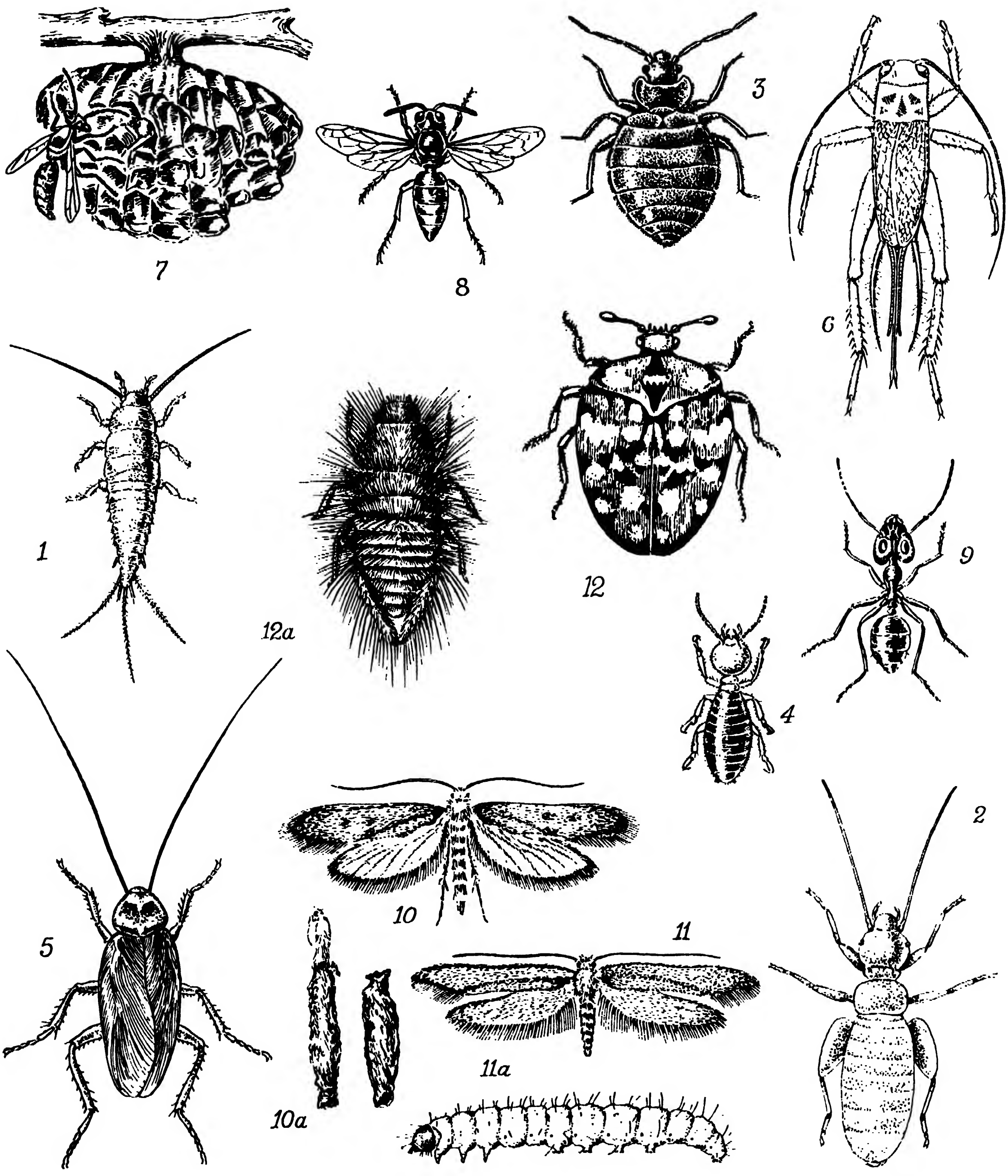
Bedbugs (*Cimex lectularius* Linn. and *C. rotundatus* Sign.: Hindi—*Khatmal*; Tam.—*Mootai*; order *Heteroptera*; family *Cimicidae*) are nocturnal household pests of dark brown colour, wingless, with a flat oval body, 6-8 mm. long and 3-4 mm. broad, inhabiting narrow crevices and hideouts where they retire during the day. The mouth parts are adapted for piercing and sucking. Both sexes are blood-suckers and prefer human blood, though they also readily feed on a number of other mammals and birds. A characteristic nauseating odour, due to a secretion from the stink glands, is associated with the bedbug.

During its life time of 3–10 months, an adult female lays about 200 eggs cemented to the material on which it rests during day time. Nymphs hatching out resemble the adult in general appearance and become adults is 2–8 weeks. The adults can live for long periods, even months, without food, but they feed actively when in contact with a warm-blooded animal.

Though not directly involved in the transmission of any disease, they cause considerable annoyance and loss of vitality in the host due to their vicious bites and voracious blood-sucking habits. Some individuals are highly allergic to bug bite and may develop extensive skin rashes.

As control measures, beds should be disinfected in the sun with applications of insecticidal sprays; application of boiling water to joints of furniture is fairly effective. Residual insecticides, such as DDT, BHC, Dieldrin, Malathion and Diazinon, especially in an oily base, afford adequate control.

Clothes moths (Order *Lepidoptera*, family *Tineidae*) are some of the smallest and oldest known household pests. The damage is caused only by their larval stages. Four species commonly occur in India, viz. *Tinea pellionella* (Linn.) or case bearing moth, *Tineola bisselliella* (Hummel) or webbing clothes moth, *Trichophaga abruptella* Woolas, or tapestry moth and *Borkhausenia pseudospretella* Staint. or false clothes moth. The case bearing moth is greyish-yellow in colour with inconspicuous dark spots on fore-wings; hind wings are silky and whitish. The larva lives inside a flattened tightly woven silky cocoon and feeds on furs, feathers, woollens, carpets, rugs, stuffed birds, clothes, and stuffings and coverings of upholstered furniture. The female lays pearly white eggs singly or in groups, either loosely upon or between folds of fabrics and at bases of hairs in furs and skins. Eggs hatch in a week's time. The newly hatched caterpillar is whitish in colour and immediately starts making a silken case for itself, in which it moves about with its head and legs protruding. The larva pupates within its case and the moth emerges in a week's time in summer and in about a




## HOUSEHOLD PESTS

**1. Silverfish** (*Lepisma saccharina*) (×3) **2. Book louse** (*Liposcellis transvallensis*) (×28) **3. Bedbug** (*Cimex lectularius*) (×7½) **4. Termite worker** (×5) **5. Common cockroach** (*Periplaneta americana*) (×¾) **6. House cricket** [*Acheta* (*Gryllus*) *domestica*] (×2) **7. Indian yellow wasp** (*Polistes hebraeus*) (×6/7) **and its nest 8. Indian hornet** (*Vespa orientalis*) **(nat. size) 9. Black ant** (*Camponotus compressus*) (×4) **10. Case bearing moth** (*Tinea pellionella*) (×4); **10a. cases with moth inside 11. Webbing clothes moth** (*Tineola bissellhella*) (×3); **11a. larva** (×5½) **12. Woolly bear beetle** (*Anthrenus vorax*) (×12); **12a. larva** (×7)

month in winter. The webbing clothes moth is uniformly pale in colour with unspotted wings. The habits of, and nature of damage by, the larva are almost similar to those of the preceding species; in this case, however, the larva moves about freely spinning silken threads at random and forming flimsy tube-like shelters in which it hides and sheds its skin. The full grown caterpillar is 3/8 inch long and white in colour. It may take four years to reach the full grown stage. It pupates inside a dense silken cocoon, and the adult emerges in about a fortnight. The caterpillars of tapestry moth generally feed on coarse and heavier fabrics like carpets, heavy blankets, tapestries, feltings, furs, skins, etc. They usually construct burrows or galleries lined with silk throughout the infested material, thus spoiling more than they actually eat. The caterpillar is about 2/5 inch long, cylindrical and yellowish dirty white in colour. The caterpillars of false clothes moth are omnivorous feeders causing damage not only to carpets and woollens, but also to food grains, flour, bindings of books, corks, etc. The full grown caterpillar is 3/4 inch long, shiny white in colour, sparsely clothed with yellowish hairs, and makes a dense silky cocoon in which it pupates.

The control of these pests is obtained by the same methods as applied in the case of carpet beetles.

Carpet beetles (Order *Coleoptera*, family *Dermestidae*) are common household pests found in association with clothes moths. Two species, *Anthrenus vorax* Waterh., the carpet beetle popularly known as 'woolly bear', and *Attagenus piceus* Oliv., popularly known as 'black carpet beetle', are common in India. The actual damage is done by their larvae and every type of woollen fabric or hair used in upholstery and in textiles and feathers, fir and silk is attacked by them.

The adult beetle of *Anthrenus vorax* is oval, 1/8 inch long, dark in colour, mottled white and black. The female lays whitish eggs in warm places under carpets, in feathers of cushions or pillows. The tiny grubs hatching out of the eggs start feeding immediately. Full grown grub is about 1/4 inch long, brown in colour and covered with tufts of short, stiff hairs. It can withstand cold and lack of food for long periods, even up to 10 months. Under favourable conditions, it pupates in two months' time and after another fortnight the adult emerges from the pupa.

The adults of *Attagenus piceus* are small, oval black beetles, 1/5 inch long. The larvae are slender, tapered, reddish brown grubs with a characteristic tuft of long hairs at the end of the abdomen. Its life history is almost similar to that of *Anthrenus vorax*. The grubs damage rough textiles, eating small holes and fibres from their free ends: in the case of furs, the hairs are eaten from their roots, thus causing them to fall in tufts. The grubs also feed on silk, dried animal remains and cereals and cereal products. The larval stage usually lasts for a year, but under adverse conditions it may last up to 3 years.

In general it is easier and cheaper to avoid infestation than to eradicate it. Care and industry must be exercised in cleaning out corners and removing of dust from cracks and crevices. Liberal use of naphthalene flakes either alone or in combination with paradichlorobenzene affords protection to woollen goods; fumigation of rooms with suitable fumigants, such as HCN or methyl bromide, may be resorted to, to rid carpets and upholstered furniture of these pests. Sprinkling of 10% DDT dust under carpets, etc. will also afford necessary protection.

Ants (Order *Hymenoptera*, family *Formicidae*, e.g. *Monomorium gracillimum* Smith, *Myrmicaria brunnea* Saund., *Solenopsis geminata* Fabr. and *Camponotus compressus* Fabr.) are tenacious pests of man from the tropics to the upper temperate regions. They have a most highly developed social system. Each colony is made up of workers, the males or drones and the queen. The workers, which are wingless, are undeveloped females and do all the work of the colony. They feed the queen and the helpless larvae. They watch over the cocoons (often erroneously called 'ant eggs'), milk the ant-cows (aphids), fetch and carry other food, and keep the galleries and chambers of the colony clean. The drones and the queens have wings, but in females they are lost after mating when either such females form a new colony or settle down in an old one. The drones do not return to the colony after mating and soon die.

The food habits of ants are varied. They thrive on practically all types of food that man consumes. A number of species live in colonies outside, but frequently invade kitchens and stores. They are not directly involved in the transmission of infectious diseases but can cause considerable pain and annoyance by biting and injecting formic acid. Certain species, like the Foie ant, inflict severe injury to man through their bite, sometimes resulting in death.

Residual insecticides, particularly Chlordane and Dieldrin, are effective in ant control. Since most ants

have outdoor colonies, control measures should include spraying of the colonies, places where they collect their food and points of entry into human dwellings.

Wasps and hornets (Order *Hymenoptera*, family *Vespidae*) often occur in and around dwellings and may become a nuisance because of their habit of stinging when disturbed. There are many species of wasps, two of which are important. *Polistes hebraeus* Fabr., the common Indian yellow wasp, constructs papery nests moulded into hexagonal cells hanging vertically with the openings downwards, in and around dwellings in verandahs, eaves, ceilings or rafters, or in any convenient spot. *Vespa orientalis* Fabr. is one of the common Indian hornets, reddish brown with some yellow markings and is frequently found feeding on sweet substances in market places. It makes completely enclosed clay nests, indoors or outdoors. Both the above species are predaceous on other insects but are also avid feeders on sweet substances. Their sting is very painful, and often poisonous. Their nests and the nest inmates may be destroyed by the application of insecticidal sprays or by burning them with a flame-thrower, after dusk when the wasps are less active and most of them are in their nests.

*Outdoor Nuisance Pests*

Although a number of outdoor blood-sucking insects, such as simulids (*Simuliidae*), chrysops (*Tabanidae*) and culicoides (*Ceratopogonidae*), have been incriminated as vectors of filarial infections in other countries, they are not of importance as carriers of diseases in India.

Blackflies or buffalo gnats (Order *Diptera-Nematocera*, family *Simuliidae*, e.g. *Simulium indicum* Bech. and *S. himalayensis* Puri) are dark, small stout bodied hump-backed flies, with short broad wings, and are easily recognised by their annulated antennae which project forward like a pair of horns. Eyes are large and close together in males, but widely separated in females. Both sexes feed on nectar of flowers, but females also feed on blood, which is essential for the development of their eggs, and are vicious biters. Unlike mosquitoes they bite only during the day. Frequently their bites are not felt when first inflicted, but the poison introduced with bite often causes swelling and lesions which may remain sore for days.

Simulids breed in fast running streams, the larvae firmly sticking, by means of suckers, on rocks, branches of trees, vegetable debris and aquatic vegetation. The larva, after six months, changes into a pupa inside a wall-packet like cocoon. The pupal stage lasts for about 4 days and the adults which emerge are powerful fliers dispersing 6–12 miles from the breeding places.

DDT is toxic to simulid larvae and adults. For the control of larvae in a stream, 5–10% DDT in fuel oil is applied at the rate of 0.1 ppm for about 15 minutes above the point where larvae are breeding. This dosage is sufficient to eliminate simulid larvae for several miles down stream. Lindane similarly applied at the rate of 0.2 ppm will also kill larvae and pupae. Repellents like DMP and Rutgers 612 afford considerable protection against the bites of these flies.

Horseflies (Order *Diptera-Brachycera-Orthorrhapha*, family *Tabanidae*—e.g. *Chrysops* spp.) are moderate sized, robust flies with strong sucking mouth parts, and diurnal in habit. They are swift and powerful fliers, persistent and aggressive in attack, and most abundant in swampy forest areas. Their bite is painless but causes considerable irritation and local swelling. Only the females are blood suckers. Eggs are laid in a compact mass on aquatic plants and other vegetation overhanging pools, swamps and other watery places, along the edges of which the larvae breed under favourable conditions; eggs hatch out in 4–7 days. The larvae feed voraciously on dead organic matter and migrate to a comparatively dry place to pupate. Adults emerge in about 2 weeks.

The application of DDT spray at 0.25–2 lb. per acre or Lindane at 0.5–1 lb. per acre results in appreciable reduction in the number of biting adults. Oil applied on stagnant pools kills adults and young larvae as they fall into the water from overhanging vegetation. No very satisfactory control of these flies has yet been devised. Repellents provide a certain degree of protection from the bites.

Culicoides (Order *Diptera-Nematocera*, family *Ceratopogonidae* e.g. *Ceratopogon* sp.) are tiny flies, commonly called midges or gnats, sometimes wrongly described as sandflies. Females are obligatory blood suckers and bite soon after sunset, causing nettle-like pricks, sometimes resulting in intense burning and severe itching. They are readily attracted to light. Eggs are laid in large clusters on decaying vegetation in moist situations and swampy waters. The larvae, which hatch out, swim about in a spirochaete-like movement. Pupae closely resemble those of mosquitoes, and adult flies emerge in 3–7 days.

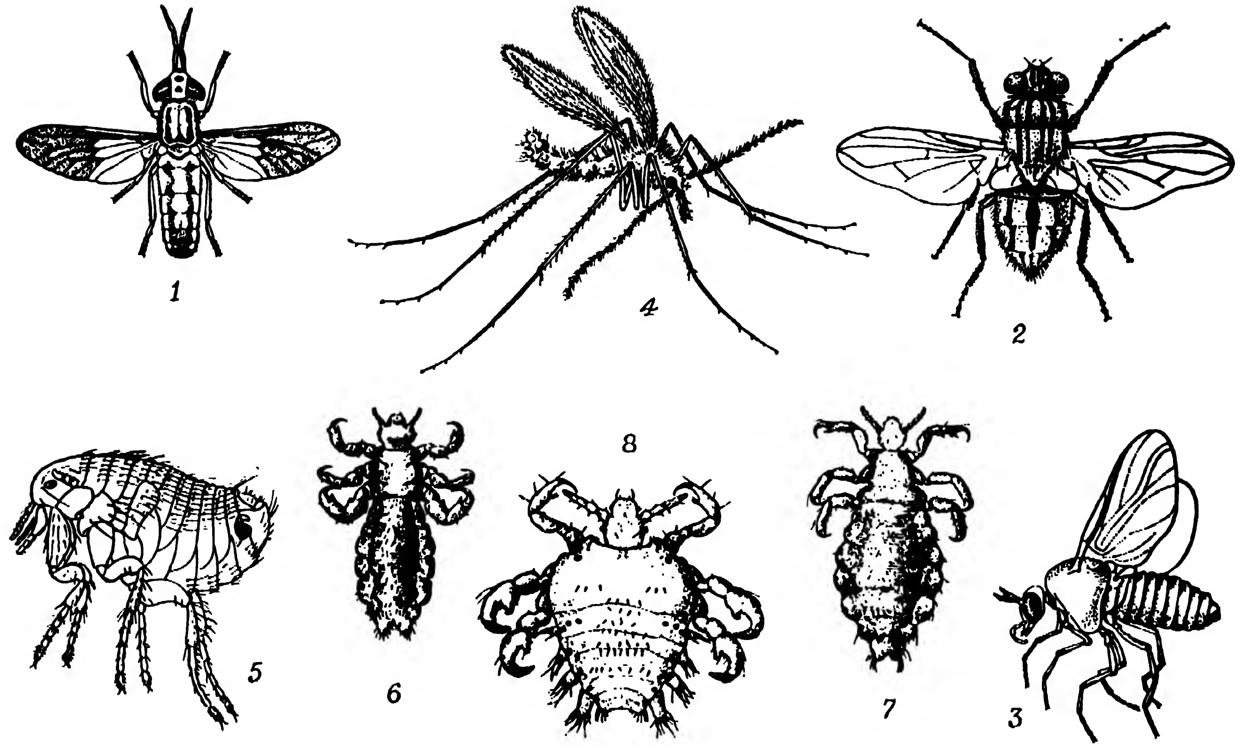



FIG. 125. INSECT PESTS OF HUMAN BEINGS: 1—HORSEFLY (CHRYSOPS SP.) (×2½) 2—HOUSEFLY (MUSCA DOMESTICA LINN.) (×4½) 3—BLACKFLY (SIMULIUM INDICUM BECH.) (×8) 4—SANDFLY (PHLEBOTOMUS PAPATASII SCOP.) (×14) 5—PLAGUE FLEA (XENOPSYLLA CHEOPIS ROTH.) (×14) 6—HEAD LOUSE (PEDICULUS HUMANUS CAPITIS DEG.) (×15) 7—BODY LOUSE (PEDICULUS HUMANUS CORPORIS DEG.) (×8) 8—CRAB OR PUBIC LOUSE (PHTHIRUS PUBIS LINN.) (×30)

Breeding of culicoides is rather difficult to control. The application of 1–2 lb. of DDT or Chlordane, or 0.5 lb. of Lindane or Dieldrin per acre reduces infestation for a long time. Dimethyl phthalate (DMP) or a combination of 6 DMP + 2 Rutgers 612 + 2 Indolone affords protection against bites.

*Disease Transmitters*

Lice (Order *Anoplura*, family *Pediculidae*—e.g. *Pediculus* spp.) are wingless, blood-sucking, dorsoventrally flattened insects with mouth parts adapted for piercing and sucking; legs are provided with strong claws which help in clinging to hair or cotton fibres; females are generally larger than males. Eggs (nits) are laid glued to the hairs; nymphs resemble the adult and moult thrice before growing to sexually mature adults.

Lice live in intimate contact with man, especially in overcrowded and insanitary conditions. Three common types infest man, viz. the body louse, *Pediculus humanus corporis* deG.; the head louse, *P. humanus capitis* deG.; and the crab louse or the pubic louse, *Phthirus pubis* Linn. The body louse is responsible for the transmission of rickettsial organisms, *Rickettsia prowazekii*, causing epidemic typhus, *R. quintana*, producing trench fever, and a spirochaete, *Borrelia recurrentis*, causing relapsing fever. Louse infestation causes considerable itching, scratching and secondary infection, leading to thickening and pigmentation of skin and matting of hair, described as vagabond's disease.

Observance of hygienic conditions, avoidance of overcrowded places, bathing and laundering and ironing of clothes are effective methods of warding off louse infestation. Shaving and burning of hair are useful in fighting large scale infestations in congested places, e.g. in prisons and concentration camps. Infestation can also be controlled by applying pyrethrum, derris, DDT or BHC dust to the hair and blowing the dust into sleeves of shirts and legs of pants. Fumigation with methyl bromide or ethylene dibromide is also effective against body lice on clothing. In the case of nits, two or three fumigations at weekly intervals may be necessary to get rid of broods hatching out. Human lice resistant to DDT are controlled by fumigation with ethylene dibromide.

Houseflies (Order *Diptera-Brachycera-Cyclorrhapha,* family *Muscidae* e.g. *Musca domestica* Linn.) are almost ubiquitous, and one of the most intimately associated pests of man. They are easily distinguished from other house frequenting flies by their mouse-grey colour with two or four narrow black stripes on the thorax, large eyes, a soft sucking proboscis and a pair of wings with characteristic venation. Mouth parts are adapted for sucking only and the fly is incapable of biting. It is mostly a foul feeder and is strongly attracted to dead and decaying animal or vegetable matter and human excrement.

The female fly deposits its eggs in irregular clusters of 75–150 in dark crevices in or directly on horse manure, cattle dung and human faeces. The duration of the larval stage varies with temperature and the quality of food available. A single female housefly may produce billions of descendants from the middle of April to the middle of September.

The housefly feeds on anything soft and moist. To feed on solid substances, like sweets and dried milk, it ejects a small drop of liquid out of its stomach and sucks up the dissolved material, leaving behind some of the disease producing germs contained therein. Owing to its untiring activity and its habit of flitting from one form of food to another and taking a little food at a time, a single fly can contaminate a number of articles of food within a short time. Contamination of food and transmission of disease are effected also through bristles on legs and body. If the flies carry germs of any particular disease, the chances are that they will be deposited along with their faeces wherever they chance to alight. They are a mechanical transmitter of typhoid, cholera, bacillary and amoebic dysentery, tuberculosis, leprosy and, at times, some helminthic infections.

The most effective and desirable method of control is to eliminate or reduce breeding places by proper disposal or chemical treatment of manure, garbage and night soil or prevent egg laying in them. To be effective, these measures should be organised on a community-wide basis, as one neglected heap may infest the whole neighbourhood. Control of adults in dwellings may be achieved by proper screening and/or by spraying chlorinated organic insecticides, such as DDT, BHC, Chlordane, Dieldrin, or organophosphoric insecticides, such as Malathion and Diazinon, as space sprays or residual sprays. For space spray, pyrethrins are very effective. Adhesive or poison baits are also effective as control measures.

Maggotflies (Order *Diptera-Brachycera-Cyclorrhapha,* family *Calliphoridae*—e.g. *Chrysomyia bezziana* Ville) seldom enter houses. Females are attracted by the odour of blood and discharges from diseased tissue and oviposit in or near the wound. Maggots on hatching out penetrate into the wound, but not into healthy unbroken tissue, and produce various forms of cutaneous and wound myiasis, as well as nasal, oral, aural, ocular and vaginal myiasis.

*Musca domestica* Linn. (Family *Muscidae*), two species of *Calliphora* and two species of *Lucilia* (Family *Calliphoridae*), the meatfly, *Sarcophaga ruficornis* Fabr. (Family *Sarcophagidae*), and *Aphiochaeta scalaris* Brues (Family *Phoridae*) also cause myiasis.

Eyeflies or mangoflies (Order *Diptera-Brachycera-Acalypteratae,* family *Chloropidae*—e.g. *Siphunculina funicola* deMeij.) are small flies, c. 2 mm. long, with shining black body and yellowish legs, very common in East and South India. They have the habit of hovering in front of eyes, making a buzzing sound, and if allowed to settle, they crawl into the corner of the eye and feed on secretions. They are responsible for the spread of conjunctivitis.

Eyeflies breed in moist mud contaminated with decomposing organic matter, grass thatch bordering roofs of dwelling houses, and in the vicinity of improperly kept latrines, stables and surface drains.

Mosquitoes (Order *Diptera-Nematocera,* family *Culicidae*—e.g. *Culex fatigans* Wied. and *Anopheles culicifacies* Giles) are slender insects with long delicate legs. The colour, which is due to a covering of scales, varies in different species. Mosquitoes generally rest in human habitations and animal shelters. The females feed on warm blooded animals and are provided with long needle-like mouth parts adapted for piercing and sucking. The male mosquitoes cannot pierce the skin and live on liquid foods. Light, air movements, temperature and humidity, as well as the attractiveness of the host animal, influence the biting of mosquitoes. Only the female mosquitoes, which can feed on blood, are capable of transmitting disease by injecting small amounts of saliva, containing parasites, into their victims.

Mosquitoes breed in water, the nature of which may be variable. Some species breed in clean water, while others like stagnant pools which may be heavily

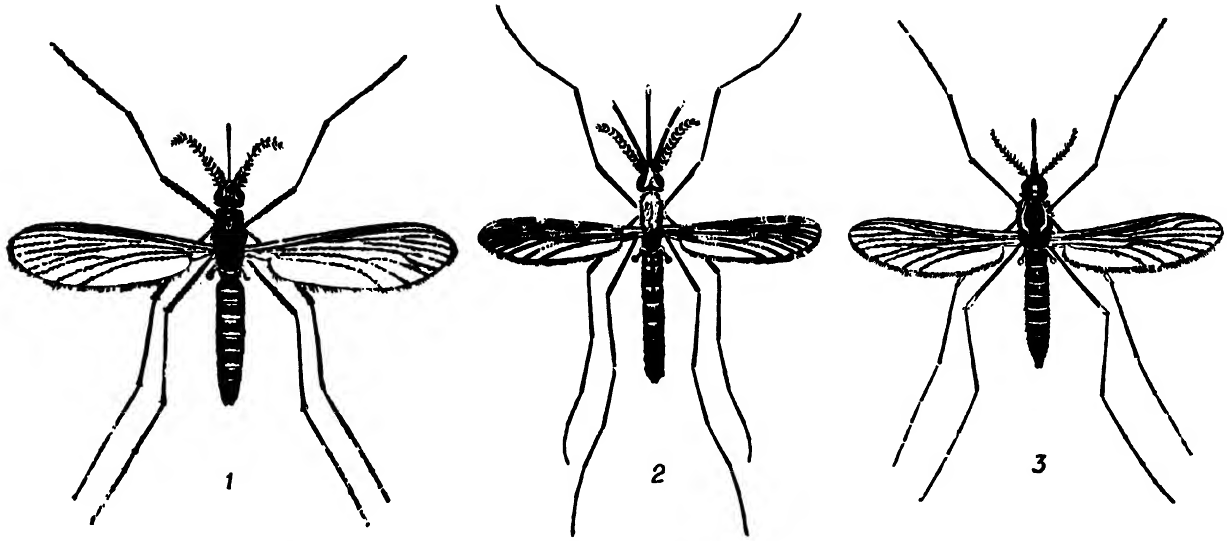



FIG. 126. INSECT PESTS OF HUMAN BEINGS—MOSQUITOES: 1—CULEX FATIGANS WIED. (×7) 2—ANOPHELES CULICIFACIES GILES (×6½) 3—AEDES (STEGOMYIA) AEGYPTI LINN. (×6)

contaminated with sewage. Eggs are laid on water and hatch out into long actively wriggling larvae, which feed, grow and moult in water. The whole life cycle takes 8–15 days depending upon the temperature and the available food.

Out of the 40 species of anopheline mosquitoes known in India, only about nine have so far been incriminated as vectors of malaria, viz. *Anopheles culicifacies* Giles, *A. minimus* Theo., *A. fluviatilis* James, *A. stephensi* List., *A. sundaicus* Rodenw., *A. annularis* Van der Wulp, *A. philippinensis* Ludl., *A. varuna* Iyen. and *A. leucosphyrus* Dön. Filaria is transmitted by two species of the mosquitoes, viz. *Culex fatigans* Wied. and *Mansonoides annulifera* (Theo.). *Aedes* (*Stegomyia*) Meig. group of mosquitoes transmits dengue.

The control of mosquitoes is achieved by measures directed against the larval and adult stages. Crude oil, Paris green, DDT, BHC, Dieldrin and Malathion have been used for controlling larvae. To eliminate breeding, draining and filling of stagnant water are recommended. Larvae of *Mansonoides* spp., which breed in association with water plants, can be controlled by using herbicides which destroy the plants. Larvicides applied on the surface of water have no effect on the breeding of these larvae. An anopheline mosquito taking a blood feed from an infective malarial patient becomes infective after at least 10 days. In order to control malaria transmission, it is, therefore, necessary to cut down the life of mosquitoes below 10 days. This is achieved by destroying adult mosquitoes in houses by pyrethrum space sprays applied three or four times a week or by applying residual insecticides in the form of a suspension or emulsion on walls, ceilings and other places, where adults are known to rest. DDT applied at the rate of 100–200 mg. per sq. ft. of wall surface has given good results, and in some parts of India the disease has been completely eradicated by this method. Culicine mosquitoes quickly develop resistance to chlorinated hydrocarbons and as their larvae have developed a large degree of tolerance to such insecticides, organo-phosphoric insecticides, like Malathion, have to be used for their control. A dose of ½ lb. Malathion per acre for controlling larvae and of 25 mg. per sq. ft. of wall surface for controlling adults is effective. Protection from mosquito bites is obtained by screening homes with wire netting and by the use of mosquito nets. Repellents like DMP applied to exposed parts repel mosquitoes.

Sandflies (Order *Diptera-Nematocera*, family *Psychodidae*—e.g. *Phlebotomus* spp.) are small, pale coloured, delicate, nocturnal insects. Their bodies and wings are densely covered with hairs ; wings are short and broad with characteristic venation. Sandflies are easily recognised in the living condition when at rest by the position of their wings which are held upright forming a 'V'. Mouth parts are adapted for piercing and sucking and females suck blood. They rest during day time in dark corners in houses and in masonry cracks in stone walls, excavations, animal burrows, hollow trees and deep cracks in soil outdoors.

Sandflies deposit their large-sized eggs in damp dark crevices in rocks and in walls, where there is sufficient moisture and abundance of organic matter for the development of larvae. Larvae undergo three moults to become pupae and complete the life cycle, egg to adult, in six to eight weeks.

Apart from being vicious biters causing great annoyance, sandflies have been known to transmit kala-azar, oriental sores and papatsi or sandfly fever. Of the species of sandflies known in India, *Phlebotomus argentipes* Ann. & Brun., *P. papatasii* Scop. and *P. sergenti* Parr. are important as carriers of human diseases.

DDT application as a residual spray, in and around houses, is effective in controlling sandflies. In the case of sandflies which have become resistant to chlorinated hydrocarbon insecticides, Malathion is found very effective. DMP repellent is useful in preventing bites.

Fleas (Order *Siphonaptera*, family *Pulicidae*—e.g. *Xenopsylla* spp.) are small, brown, broad bodied insects flattened from side to side. They are wingless but have powerful, long hind legs used for jumping. Both sexes have strong mouth-parts adapted for piercing and sucking. A large number of species occur in India; some are found on the common rat, *Rattus rattus*. The adults live mostly attached to bodies of rodents, and eggs are laid in rat burrows. The wriggling larva hatching out feeds on the debris in the rat burrows. Mature larva pupates in a cocoon out of which the adult emerges in a few days. The entire life cycle of *X. cheopis* Roth. takes 21–22 weeks under normal Indian conditions. Adult fleas can live for 5–6 weeks without food.

Of the three species, *X. cheopis* Roth., *X. astia* Roth. and *X. brasiliensis* Bak. occurring on rats, *X. cheopis* is the most important carrier of plague in India. The plague bacillus, *Pasteurella pestis*, is an infection of the rodent population, chiefly the house rat, and fatal to it. When there is a reduction in rat population due to high mortality from plague among them, the fleas are forced to leave the cold carcasses of dead rats and seek other warm blooded animals, nearest of which are the residents of houses where 'rat falls' occur. Man is thus only an accidental victim to the infection. In addition to mechanically harbouring and transmitting the infection, fleas act as culture tubes in which the organisms multiply.

Fleas have also been incriminated as intermediary agents in the transmission of certain other diseases, like endemic typhus, and of certain tape worms of dogs and cats (*Diphilidium caninum*) which infect man only accidentally.

Flea infestation can be prevented by observance of strict hygienic conditions, with steps taken simultaneously to eliminate rats in dwellings, food stores and godowns. Infested places should be treated with 5% DDT emulsion; and dust containing 5% DDT should be blown into rat burrows and between bags in godowns. If fleas have become resistant to chlorinated hydrocarbon insecticides, organo-phosphorus insecticides like Diazinon and Malathion will prove effective. Cyanogas is a powerful rodenticide but should be used with proper precautions to control rats in houses and in other establishments.

### General Methods of Insect Pest Control

Pest control implies the adoption of measures designed to prevent infestation by pests or to destroy them if infestation has already occurred. It does not necessarily and always mean the complete eradication of pests, but only reduction in their incidence to the point of harmlessness. Control measures must be effective, non-injurious, economical and feasible, and satisfactory in other respects. Broadly speaking, methods of pest control can be classified under five heads, namely mechanical control, cultural control, chemical control, biological control and legislative control.

#### *Mechanical*

Mechanical control includes the employment of measures to remove or to destroy pests or pest-affected plants or parts thereof by hand picking or hand nets, ploughing, digging, hoeing, burying underground and burning. Driving locust hoppers into trenches and burying them, burning locusts by flame-throwing guns and thorough and periodical cleaning of grain and godowns are also mechanical measures of pest control. In the case of pests which are attracted to light, light traps, usually a Dietz lantern or a petromax lamp placed in the midst of a wide and shallow basin of water with a film of kerosene oil on top, are set up with the object of destroying them. Employment of acoustic signals based on the study of phonoreactions of insects has application in pest control.

#### *Cultural*

Cultural control involves the introduction of new farming practices or the modification of those already in vogue with a view to destroying insects or creating

conditions adverse to their multiplication and spread. Changing of cropping patterns, alterations in the times of sowing and harvesting, increase or decrease in the frequency and amount of irrigation water, attention to drainage, judicious use of manures and fertilizers, removal of weeds and of alternate hosts of pests, proper spacing of plants and pruning of trees to ensure sufficient space and sunlight, and avoidance of crop varieties susceptible to pests are among the main cultural measures employed to control plant pests. The adoption of these measures is conditioned by a variety of factors and circumstances which it may not always be easy or feasible to surmount. Using resistant varieties of crops to prevent pest attacks is essentially a cultural method of control, which is dependent upon a variety of factors and circumstances, and liable to break down when any of these is absent or upset.

*Chemical*

Chemical control involves the use of various poisons in the form of sprays, dusts, baits, fumigants and aerosols to destroy or repel insects in order to protect agricultural crops and stored produce. These measures have become increasingly popular since they yield quick and demonstrable results at economic costs. A wide variety of chemicals are used, either alone or in combination with solvents and synergists. In recent years, a variety of organic insecticides have been synthesized and are being increasingly used in place of inorganic poisons and natural insecticidal plant materials, such as derris, pyrethrum and tobacco. Names of some important organic and inorganic insecticides are given below:

*Synthetic Organic Insecticides*

DDT (Dichlorodiphenyltrichloroethane)
Methoxychlor (Dimethoxydiphenyltrichloroethane)
TDE (Tetrachlorodiphenylethane)
DCPM (Dichlorophenoxymethane)
BHC (Hexachlorocyclohexane)
Lindane (Hexachlorocyclohexane, gamma isomer)
Chlordane (Octachlorohexahydromethanoindene)
Aldrin, HHDN (Hexachlorohexahydroendoexodimethanonaphthalene)
TEPP (Tetraethyl pyrophosphate)
Schradan, OMPA (Octomethyl pyrophosphoramide)
Parathion (Diethylnitrophenyl thiophosphate)
Malathion (Dimethyl dithiophosphate of diethyl mercaptosuccinate phenothiazine)
Rhodanates (General name for thiocyanates)
Arathone (Dinitrocaprylphenyl crotonate)
Allethrin (Synthetic product allied to pyrethrin)

*Natural Organic Insecticides*

Tobacco (Nicotine, nicotine sulphate and nornicotine)
Pyrethrum (Pyrethrin)
Derris (Rotenone and rotenoids)
Sabadilla
Hellebore
Various oils and coal-tar distillates

*Inorganic Insecticides*

Arsenates and arsenites of calcium, copper (Paris green), magnesium, sodium and lead
Fluorides, fluosilicates and other fluorine compounds
Compounds of mercury, thallium and selenium
Phosphides
Cyanides
Sulphur compounds

Some of the insecticides act as stomach poisons; some are contact poisons, and yet others are systemic poisons. Among the important stomach poisons are: BHC, DDT, Methoxychlor, lead arsenate, calcium arsenate, Paris green, sodium fluoride, cryolite, fluosilicates and compounds of borax, thallium, phosphorus and mercury. Contact poisons kill insects through direct contact; important among them are: BHC, DDT, Toxaphene, Chlordane, Dieldrin, Aldrin, Endrin, Methoxychlor, nicotine, lime-sulphur, oil emulsions, pyrethrum, rotenone, synthetic thiocyanates and organic phosphorus compounds. Systemic insecticides are of recent origin: they are readily absorbed by growing plants and translocated in the plant system, in concentrations sufficient to render the sap lethal to insects; sodium selenite, sodium fluoroacetate, Schradan, Systox and Thimet are effective systemic poisons.

Fumigants are particularly valuable in destroying plant borers and other forms of pests which inhabit places inaccessible to liquid insecticides; among the more important fumigants mention may be made of hydrogen cyanide, carbon disulphide, carbon tetrachloride, nicotine, sulphur dioxide, *p*-dichlorobenzene, naphthalene, chloropicrin, ethylene oxide and dichloride, and methyl bromide.

The handling of insecticides in the field, godowns, sheds, etc., is accompanied by hazards to domestic animals and operators, and proper precautions should, therefore, be taken to guard against such hazards. Their successful use demands an appreciation of the tolerance limits of the pest, plant or animal.

*Biological*

Biological control is based on the fact that practically every plant and animal in nature has its enemies in the shape of plant feeding animals, predators and parasites, which constitute part of the biological limitations of its environment. The method consists in artificially employing one or more natural enemies of the pest to reduce its population to the point of harmlessness. The natural enemies may be of animal, fungal, bacterial or virus origin, effective against one or more stages of the pest—Ladybird beetles feed on aphid and coccid pests; parasitic wasps and flies lay eggs in some caterpillar pests; some fungi and bacteria produce diseases among insect pests and other animals; some insects feed on weeds to the extent of exterminating them.

Legislative methods of pest control are twofold, namely plant quarantine and national and local laws and rules for the control of specific pests and diseases.

## Beneficial Insects

While the damage caused by injurious insects is no doubt considerable, the contribution of beneficial species to national prosperity should not be overlooked.

*Insect Pollinators*

Insect pollinators are mainly responsible for fertilization in some of the major crops, such as pulses, tobacco, pepper, oilseeds, cotton, coffee, etc., and in fruit trees, and the benefit derived through pollinating insects alone is estimated to be much more than the total loss caused by all insects. The insect-pollinated flowers are often characterised by special structural modifications which compel various species of insects that come for nectar to carry away pollen grains from one flower to another and thus ensure cross pollination. Most flower-visiting insects also have special structures for collecting and transporting pollen grains from the flowers they visit.

Not all insects that visit flowers are, however, pollinators. Many insect larvae, thrips and beetles frequently destroy flowers and only accidentally bring about pollination. Their mouth parts are not designed for feeding on nectar; they have no hairy covering for brushing away pollen grains, and no mechanism for carrying pollen loads. Others, like sphecid wasps, short-tongued bees and some butterflies, have mouth parts specially adapted for sucking nectar and their body is hairy to facilitate brushing off of pollen grains. The true pollinators are the familiar hawk moths (*Deilephila* spp.), death's head moths (*Acherontia* spp.), and other sphingid moths and the long-tongued social honey-bees; some flies, fleshflies, wasps, hoverflies and ants are also important insect pollinators. Bees have specialized pollen baskets for transport of load gathered during their visits to flowers. Just as different insects are adapted for visiting flowers, the flowers are also adapted to receive specific types of insects. The specialisations are greatly marked in figs which form a special class by themselves and are pollinated by fig insects or agaontid and chalcid wasps like *Blastophaga* spp. For the existence of the fig plant, therefore, the fig insect is necessary and the fig insect also cannot live in the absence of figs. It is generally customary to think of the honey-bees as merely the sources of honey and bees-wax, but their role as pollinators of crops, orchards and forest trees is far greater in importance.

*Insect Pests of Noxious Weeds*

Insects attack not only cultivated and economically useful plants, but also weeds in cultivated fields, gardens and orchards. The knowledge of the part played by insect pests of weeds has often been put to practical application. One of the most destructive weeds, namely the prickly pear (*Opuntia* sp.), was almost completely eradicated in South India by the introduction, from Mexico, of the tiny mealy bug, *Dactylopius tomentosus* (Linn.). Areas which were wholly impenetrable due to prickly pear bushes were converted into fertile arable lands within five or six years. Cockle-burr (*Xanthium* sp.), another equally troublesome weed, which came into India from Australia, is kept in check by the attacks of several species of insects. The lantana, another noxious weed growing in hill plantations, has also been checked to a great extent by the lantana bug, *Orthezia insignis* Dougl. (*Coccidae*), which is also known to attack other plants. The lantana seed fly, *Ophiomyia* (*Agromyza*) *lantanae* Frog. (*Agromyzidae*), which was known to be an efficient natural enemy of lantana in Hawaii and other countries, and the lantana lace bug, *Teleonemia scrupulosa* Stal (*Tingidae*), introduced from Australia, have, however, not proved useful. Investigations on the pests of water hyacinth (*Eichhornia* spp.), *Mimosa* spp., *Tribulus* spp. and *Eupatorium* spp., found in India, are in progress.

*Scavengers*

Some insects serve as scavengers by feeding on dead and decaying animal and vegetable matter. The

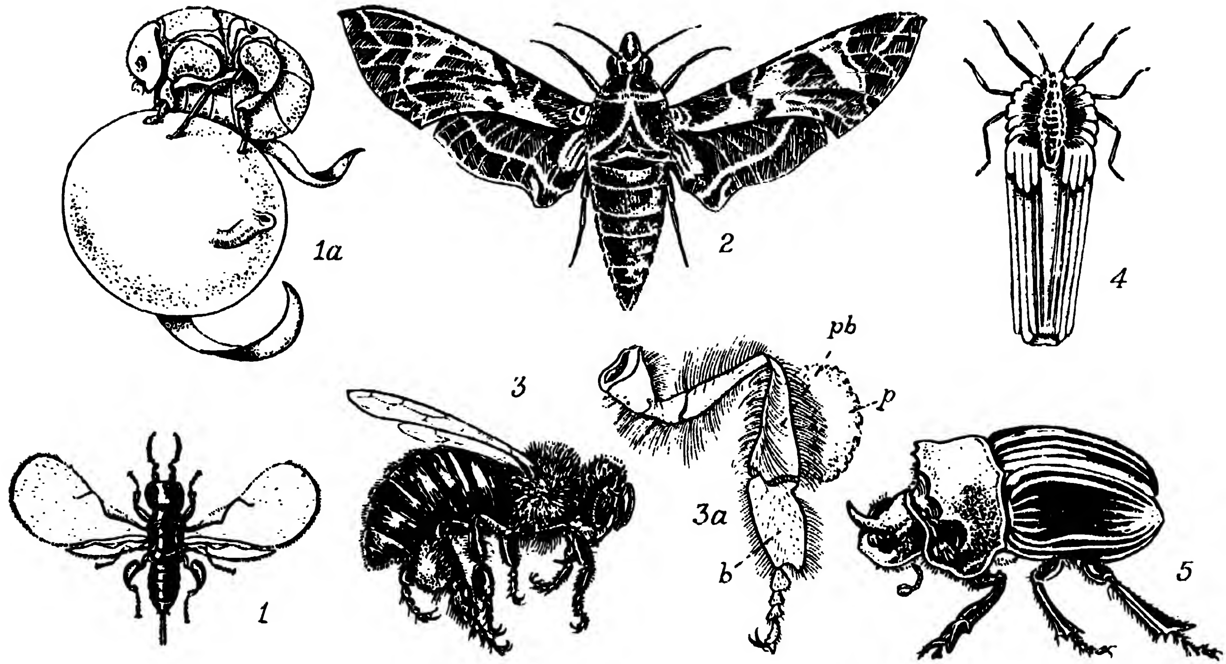



FIG. 127. BENEFICIAL INSECTS (POLLINATORS, WEEDKILLERS AND SCAVENGERS): 1—FIG POLLINATING WASP (BLASTOPHAGA SP.), FEMALE (×8); 1a—MALE FERTILISING THE FEMALE FOUND WITHIN A GALLED FLOWER OF THE FIG 2—HAWK MOTH (DEILEPHILA SP.) (×4/5) 3—WORKER HONEY-BEE SHOWING LUMP OF POLLEN ON HIND LEG (×2-3/4); 3a—HIND LEG OF WORKER SHOWING: p—POLLEN, pb—POLLEN BASKET, b—POLLEN BRUSH 4—LANTANA BUG (ORTHEZIA INSIGNIS DOUGL.) (×24) 5—DUNG ROLLER (HELIOCOPRIS BUCEPHALUS FABR.) (×2/3)

staphylinid beetles, the dung rollers or scarab beetles, *Heliocopris bucephalus* Fabr. (*Coprilidae*), beetle borers of dead wood (*Bostrychidae*), white ants (*Termitidae*), carrion beetles (*Cleridae*), beetle borers of bark, stem, etc. (*Passalidae*, *Scolytidae*, *Cerambycidae*, etc.), fleshflies (*Sarcophagidae*), hoverflies (*Syrphidae*), the screw worm flies (*Muscidae*) and a number of others act as natural scavengers.

*Predators and Parasites*

There is a large class of indirectly beneficial insects that exercises a natural check on the multiplication of harmful and destructive forms. Predatory insects hunt and feed on smaller or more helpless insects or other animals. Parasites gradually consume the substance of the host and ultimately kill it.

Predatory insects are spread over most orders of insects and a large number of families; out of these the following are important:

Mantids (Order *Mantodea*, family *Mantidae* e.g. praying mantis, *Hierodula coarctata* Sauss.) are large-sized carnivorous insects, protectively coloured to simulate the surroundings: prothorax is long and fore legs are modified into pincers for grasping prey (raptorial): they destroy numerous injurious grasshoppers, butterflies, beetles, houseflies and various other pests. About 100 species occur in India, which are known to be predatory in all stages of their life.

Dragonflies (Order *Odonata*) are large-sized slender insects with mobile head, large compound eyes, stout thorax, two pairs of long narrow wings and elongated slender abdomen. About 700 species are known in India and are commonly met with in moist localities, such as river banks, pools and marshes. Both larvae and adults are predaceous, mainly on forms belonging to *Diptera*, *Lepidoptera* and *Hymenoptera*; they capture the victims by the sweeping of wings and eat the prey held in their legs and stretched in front of the head while flying. Larvae are aquatic and predaceous on young ones of gnats, midges, mosquitoes, flies and other aquatic insects. The order as a whole is largely beneficial and serves as a natural check for mosquitoes and flies.

Lacewing Flies or Ant Lions (Order *Neuroptera*, family *Chrysopidae*) are small delicate insects, green or yellow in colour, with tough spiny skin and strong sickle-shaped mandibles. Larvae have a prodigious appetite and prey on aphids and mites

by piercing and extracting body juices. The genus *Chrysopa* has a world-wide distribution.

Beetles (Order *Coleoptera*) include several beneficial predators, chiefly in families *Carabidae, Cicindelidae, Dytiscidae, Gyrinidae, Staphylinidae, Histeridae, Cantharidae, Meloidae* and *Coccinellidae,* which attack all sorts of insects including many harmful ones. Histerids are generally predaceous on injurious chrysomelid beetles, fly larvae and caterpillars. The cantharid and meloid larvae destroy eggs of grasshoppers and locusts.

Ground Beetles (*Carabidae*, e.g. *Anthia sexguttata* Fabr.) are small to large-sized beetles with thick chitinous shell on body, dull or bright metallic in colour, long-legged and capable of running fast; they are mostly ground dwelling forms, found under stones, bark, in moss, rotten wood, etc. and active at night; larvae with elongated body, sharp projecting mandibles and a pair of bristly processes at the posterior end live in the same situations as adults. Both larvae and adults prey on various caterpillars, grubs, grasshoppers and snails.

Tiger Beetles (*Cicindelidae,* e.g. *Cicindela sexpunctata* Fabr.) are medium-sized slender beetles with long, toothed and curved mandibles and long slender legs; they are dull or bright metallic in colour with stripes or spots; grubs are cylindrical with large disc-like head and strong mouth parts and a hooked process dorsally on the fifth abdominal segment. They live in vertical or slanting holes in the ground waiting for any convenient victim that may pass by. Adults are mostly surface dwellers, preying on insects and other smaller forms.

Ladybird Beetles (*Coccinellidae,* e.g. *Coccinella septempunctata* Linn.) are small in size, oval or circular in shape, hemispherical, dull or brightly coloured, often with spots or stripes which may vary within the species and between the sexes; wings are well developed; larvae are broadly tapering, covered with warts, spines or waxy strands, and dull coloured

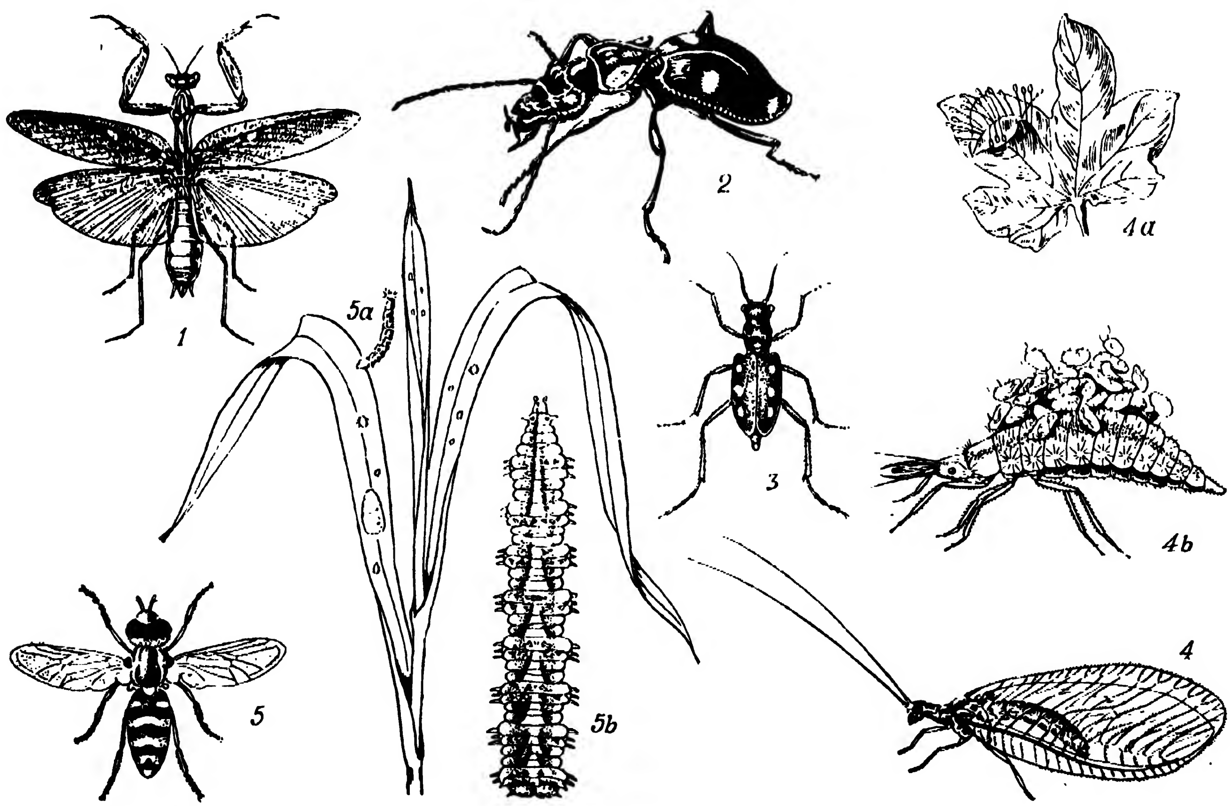
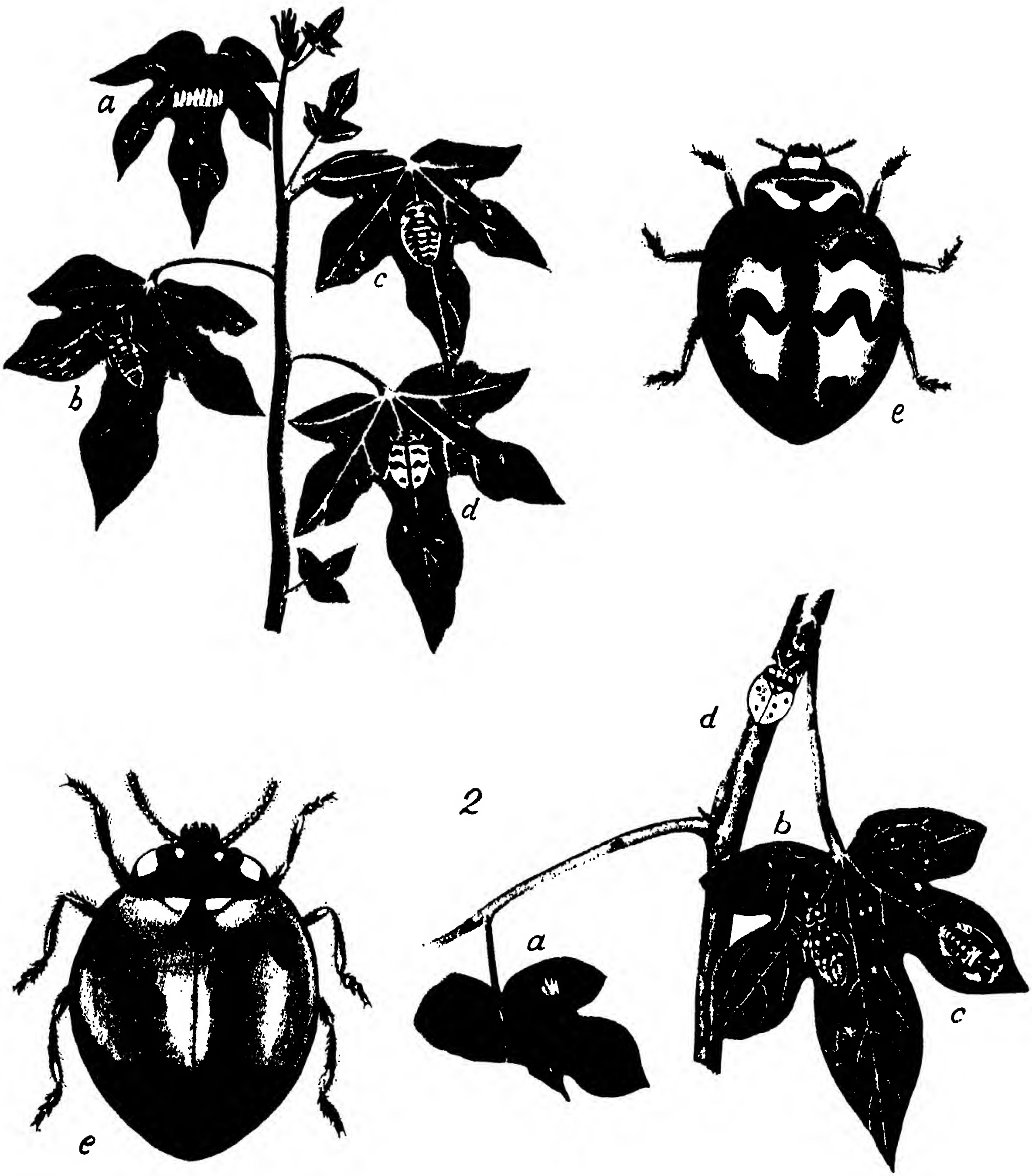



FIG. 128. BENEFICIAL INSECTS (PREDATORS): 1—PRAYING MANTIS (HIERODULA COARCTATA SAUSS.) (×½) 2—GROUND BEETLE (ANTHIA SEXGUTTATA FABR.) (NAT. SIZE) 3—TIGER BEETLE (CICINDELA SEXPUNCTATA FABR.) (×4, 5) 4—LACEWING (CHRYSOPA SP.), ADULT FLY (×4); 4a—BUNCH OF EGGS LAID ON LEAF; 4b—FULLGROWN LARVA WITH EMPTY SKINS OF APHIDS IT HAS DEVOURED (×5) 5—HOVERFLY (SYRPHUS SP.) (×2); 5a—LARVA FEEDING ON APHIDS ON WHEAT PLANT; 5b—FULL GROWN LARVA (×5)




**PREDATORY INSECTS — LADYBIRD BEETLES**

**1.** *Chilomenes sexmaculata* (×8) **2.** *Coccinella septempunctata* (×7)

**a. egg cluster; b. larva; c. pupa; d. imago; e. full grown beetle; larva and imago are shown feeding on aphids on a plant**

or splashed with bright markings. Ladybird beetles are predaceous on small insects, mites and insect eggs in both larval and adult stages. They destroy aphids, whiteflies and mealy bugs, which are particularly harmful to food crops.

On account of the narrow range of natural hosts preferred by them several species of ladybird beetles have been successfully utilized for biological control of crop and orchard pests in many parts of the world. A single larva of *Chilomenes sexmaculata* (Fabr.) is known to prey on *c.* 200 aphids a day; a larva of *Cryptolaemus* sp. feeds on *c.* 1,325 eggs of *Pseudococcus citri* Risso in its life time, and that of *Hyperaspis binotata* Say on 90 adult coccids and 3,000 nymphs. The cottony cushion scale or fluted scale, *Pericerya* (*Icerya*) *purchasi* (Mask.), a serious pest of fruit trees like citrus and wattle plantations, has been successfully controlled by the introduction of an Australian ladybird beetle, *Rodolia cardinalis* (Muls.). It feeds on the eggs and nymphs of the fluted scale in both larval and adult stages. *Cryptolaemus montrouzieri* Muls. was imported into India in 1898 for the control of citrophilus mealy bugs, *Pulvinaria* spp. The use of *Chilocorus nigritus* (Fabr.) against the green bug of coffee, *Lecanium viride* Gr., and other scale insect pests of orchard plants was attempted in Madras State in 1952-53; preliminary trials showed that this predator may be employed to supplement the chemical methods, but is not effective by itself on account of its low reproductive capacity.

Other beneficial species are: *Scymnus nubilans* Muls. which preys on aphids and sugarcane whiteflies in its larval and adult stages; *Stethorus tetranychi* Kapur feeding on mites; *Juarvia soror* Weise which preys on scale insects, citrus whiteflies and mites; and *Synonycha* spp. which check bamboo aphids.

Flies (Order *Diptera*)—Both predatism and parasitism are common among *Diptera* which, next to *Hymenoptera*, are generally entomophagous. Flies belonging to the families *Rhagionidae*, *Tabanidae*, *Ochthiphilidae* and *Chloropidae* are entirely predaceous. Members of families like *Itonididae* (midges) feed on aphids, coccids, thrips, whiteflies, psyllids and mites which are mostly injurious. Among *Sarcophagidae* and *Phoridae*, both predatory and parasitic species are known. Members of the family *Dolichopodidae* are predaceous on various insects, especially *Collembola*. Certain bombyliids, which attack many beneficial *Hymenoptera* and *Diptera*, are definitely harmful.

Hoverflies or Flowerflies (Family *Syrphidae*) are small, brightly coloured insects, visiting flowers for pollen and nectar. Larvae vary greatly in form and habits. Some are predaceous on plant aphids, some live in decaying animal or vegetable matter and others in filth. *Syrphus confrater* Wied. has been reported to feed on aphids of cotton, wheat, cabbage, chrysanthemum and mustard; in the Punjab, it feeds on woolly aphis, *Eriosoma lanigerum* Hausm.

Robberflies (Family *Asilidae*) are large elongated insects of slender build, clothed in hairs or bristles, and generally dull coloured; adults capture prey during flight; larvae are reported to be predaceous on insects living in soil debris and rotting wood.

*Leucopis luteicornis* Mall. (Family *Ochthiphilidae*) is predaceous on aphids and mealy bugs. Several chloropids often attack the eggs of various grasshoppers. The larvae of some anthomyiid flies are also predaceous on the eggs of locusts.

Assassin Bugs (Order *Heteroptera*, family *Reduviidae* e.g. *Isyndus heros* Fabr.) are medium-sized, heteropterous insects, dull or strikingly coloured, with stout curved beak; they are mostly predaceous on other insects, like aphids, leaf hoppers and caterpillars, which are injurious to crops. They suck the body juices of their victims held firmly in their spiny fore legs. The pentatomid bug, *Perillus* sp., attacks the larvae of several injurious *Coleoptera*. Some species of lygaeid bugs are also known to attack plant mites.

Ants and Wasps (Order *Hymenoptera*) constitute the dominant beneficial entomophagous insects of India. The order includes many important beneficial predators.

Ants (Family *Formicidae*) form an important predaceous family of *Hymenoptera* exhibiting a wide range of feeding habits, from plant juices to entirely carnivorous diets. Predatory ants are general feeders attacking all insects and other smaller animals, encountered on the march, which are unable to save themselves by flight. Several hundred species are known in India.

Wasps (Families *Sphecidae*, *Scoliidae* and *Eumenidae*) are pugnacious creatures, warningly coloured and equipped with a stinging apparatus for paralyzing victims. They construct mud cells or dig holes in the ground and stock them with grasshoppers, crickets, cockroaches, spiders, caterpillars and other insects, paralyzed into a state of immobility, to serve provender for grubs hatching out of their eggs.

Sphecids (*Sphecidae*) are predaceous on crickets and grasshoppers and *Bombyx* spp.; they also hunt flies. Scoliid wasps, such as *Scolia quadripustalata* Fabr. (*Scoliidae*), attack beetles. *Eumenes esuriens* Fabr. (*Eumenidae*) and *Sceliphron madraspatnam* Fabr. (*Sphecidae*) store their mud nests with paralyzed moth caterpillars.

Most thrips (Order *Thysanoptera*) are injurious to agricultural crops, but certain species of *Spolothrips* are beneficial since they destroy various species of of mites which attack crops.

*Lepidoptera* are mostly phytophagous and in many cases extremely injurious, but several predatory species are also known. The caterpillars of lycaenid butterflies destroy aphids, coccids, fulgorids and jassids. Some species of *Eublemma* (*Noctuidae*), though injurious to the lac insect, are predaceous on the coccids, *Pulvinaria* spp.

Parasites differ from predators in that they do not kill the prey but feed only on living substance of the hosts unobtrusively. They are widely met with in several orders of insects, e.g. *Lepidoptera*, *Strepsiptera*, *Hymenoptera* and *Diptera*. Some parasitic insects attack single host species only, but others attack more than one host. Every stage of every species of insects is subject to the attack of one or more species of insect predators or parasites. Some insects have a large number of predators and parasites, e.g. the common citrus mealy bug, *Pseudococcus citri* Risso, is attacked by the larvae and adults of not less than 8 different species of ladybird beetles, 6 species of parasitic and predatory *Diptera*, 4 species of chrysopids and at least 8 species of parasitic *Hymenoptera*. The insect parasites of injurious species are also often themselves attacked by other predators or parasites, resulting in secondary parasitism. The secondary parasites may often be attacked by tertiary parasites or hyper-parasites.

Some species like *Epipyrops fuligionosa* Tams (Order *Lepidoptera*, family *Epipyropidae*) are extremely beneficial parasites of the sugarcane pyrilla in India.

Stylops (Order *Strepsiptera*) constitute a small group of insects parasitic on many injurious gryllids (crickets), locusts, pentatomid, fulgorid and jassid bugs, wasps, hornets and other insects. In India, the sugarcane pyrilla is attacked by a species of stylops. The female of stylops is a degenerate wingless grub-like form, whereas the male is winged. The larvae live in the body cavity of the hosts and absorb blood and other fluids.

Wasps (Order *Hymenoptera*), such as ichneumonids, braconids and chalcids, are important parasites. Ichneumonid wasps (*Ichneumonidae*) are parasitic mostly on the larvae of *Lepidoptera, Coleoptera, Hymenoptera* and *Diptera*. Many beneficial species of this family belong to the genera *Amblyteles*, *Angitia*, *Campoplex*, *Nemeritus* and *Xanthopimpla*.

*Braconidae* and *Vipionidae* are relatively more important economically as parasites of major crop pests. Braconids parasitize larvae of *Lepidoptera, Hymenoptera, Coleoptera* and *Diptera*. *Microbracon greeni* Ashm. is an important parasite of the cotton bollworm in India. *Apanteles* spp. parasitize many injurious *Lepidoptera* including *Pieris brassicae* Linn., often a serious pest of cruciferous crops. *Opius* spp. are parasitic on maggots of fruitflies infesting cucurbits, mango, citrus, guava, ber, etc.

The *Chalcidoidea* are the most important parasitic *Hymenoptera* of which 2,000 species are known in India. They are small to minute insects with bright metallic green or blue colour. They parasitize the eggs, the larvae and the pupae of almost all orders of insects including other chalcids. Primary and various grades of hyper-parasitism are known among them. Reproduction is polyembryonic. The chalcid parasite, *Podagrion* sp., attacks egg masses of mantids. Several species of *Brachymeria*, *Chalcis*, *Smicra* and *Stomatocerus* parasitize injurious caterpillars. *Dirhinus* sp. is parasitic on fly maggots. The

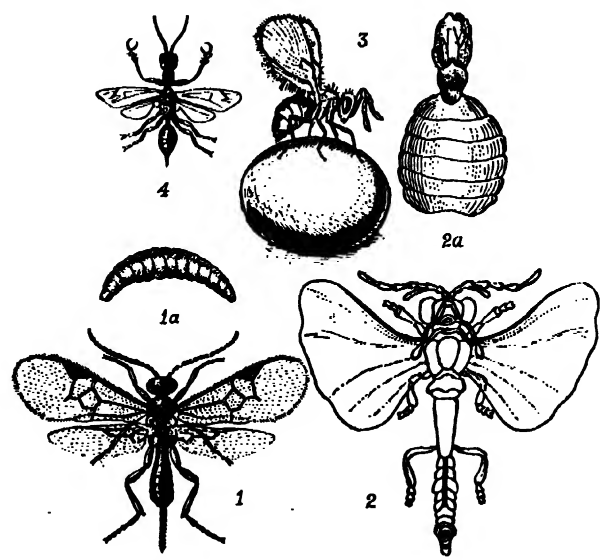



FIG. 129. PARASITES: 1—APANTELES PUSAENSIS LAL, ADULT FEMALE (×9); 1a—GRUB 2—STYLOPS SP., MALE (×9); 2a—FEMALE (×9) 3—ADULT FEMALE OF TRICHOGRAMMA SP. READY TO LAY ITS EGGS WITHIN A MOTH EGG (×16) 4—LESTODRYINUS PYRILLAE KIEFF.

family *Encyrtidae* is a natural enemy of mealy bugs, scale insects and many other injurious coccids. *Ooencyrtus pyrillae* Crawf. and *Aganiaspis pyrillae* Mani are egg parasites of sugarcane pyrilla. *Scutellista cyanea* Motsch. (*Pteromalidae*) attacks the black scale insects and *Aplastomorpha calandrae* (How.) of the same family attacks the rice weevil. *Aspidiotiphagus citrinus* (Crawf.) is a beneficial parasite, introduced into India from U.S.A. for controlling the scale insect pests of citrus.

*Trichogramma evanescens* Westw. is parasitic on the eggs of several *Lepidoptera* and has been artificially reared and released in large numbers in the field for the control of teak defoliators and sugarcane borers. *Serphoidea* or *Proctotrypoidea* include some beneficial parasites. *Scelio* sp. parasitizes the eggs of grasshoppers and locusts. *Telenomus* spp. attack the eggs of various pentatomid bugs. *T. beneficiens* Zehn. is an egg parasite of the sugarcane stem borer, *Diatroea* sp. Other species of *Telenomus* are known to parasitize the eggs of moth borers of jowar, rice, etc. *Platygasteridae* are parasitic on the larvae of gall midges including the paddy gall midge, *Pachydiplosis oryzae* (W.M.) Mani. *Amitus aleurotobi* Mani often destroys the sugarcane whitefly, *Aleurolobus barodensis* Mask. The superfamily *Bethyloidea* includes beneficial species like *Lestodryinus pyrillae* Kieff. and *Pseudogonatopus pyrillae* Mani parasitic on sugarcane pyrilla. The females catch the pyrilla nymphs, lay eggs on them and release them : a tumour-like swelling soon develops at the spot of parasitization and the host ultimately dies. The evanid wasps of which about 100 species are so far recorded in India parasitize the eggs of cockroaches. *Evania appendigaster* Linn. is a cosmopolitan species, common nearly all over India : it is a natural enemy of the loathsome domestic cockroach, *Periplaneta americana* Linn.

Flies (Order *Diptera*) belonging to the families *Cyrtidae*, *Nemestrinidae*, *Pipunculidae*, *Conopidae*, *Agromyzidae* and *Tachinidae* are parasites : in most cases, only the larvae are parasitic. The larvae of *Pipunculidae* are internal parasites of nymphs and adults of homopterous bugs. Though *Agromyzidae* are general plant feeders, *Cryptochaetum* is parasitic on the fluted scale and other giant mealy bugs. *Tachinidae* consists of the genera *Sturmia*, *Cyphocera*, *Tachinia*, *Winthemia* and *Exorista*, parasitizing pests like paddy army worm, tea slug and fruit moth larva. Other important pests, like the paddy stem borer, tobacco caterpillar, gram caterpillar, red-hairy caterpillar and paddy swarming caterpillar, are subject to the attacks of one or more wasp or fly parasites. These useful forms are utilized in the control of many crop pests.

*Insects as Food*

Insects provide the entire diet of certain birds, mammals and many fishes. A good number of food fishes occurring in rivers and tanks depend for their food largely or wholly on aquatic and other insects, such as flies and their larvae, caddisworms, beetles, mosquitoes and gnats and their larvae. Many insects are used as baits in fishing. Domestic fowls and many game and fancy birds are largely insectivorous. The food of common myna is mainly composed of grasshoppers.

Various tribes in North America and aborigines of Australia eat insects ; during times of famine, insects belonging to *Coleoptera* and other insect orders form the main food. Some insects are consumed along with apples, spinach, or other foods either as titbits or as staple diet in parts of Australia, Africa, Asia and America. In Arabia, Baluchistan and in the desert areas of Sind, locusts are collected in bagfuls, boiled, salted and dried, to be taken as food in times of need. Dried locusts are fed to camels, cattle and poultry. Cockroaches and silkworm chrysalids are eaten by the Chinese, termites and certain insect larvae by the Javanese, waterbugs by the Mexicans, cockchafers by Italian peasants and the cochineal insects and cheese mites by various European nations.

Insects are reported to be nutritious. Except for a few brief records, detailed information on food insects in India is not available. Certain insects of the orders *Coleoptera*, *Heteroptera*, *Homoptera*, *Orthoptera*, *Hymenoptera* and *Diptera* are known to be eaten.

Rhinoceros beetles (*Oryctes rhinoceros* Linn.) and their larvae are roasted with salt and eaten by the Siamese. The larvae of red palm weevil, *Rhynchophorus ferrugineus* Oliv. (a pest of coconut and other palms), *Crytotrachelus longipes* Fabr. and *C. dux* Boh. (borers of young sprouting bamboos) are collected and roasted or fried for food in Siam and in India. The white plump weevil larvae of *Protocerius fervidus* Pasc. (*Curculionidae*) are collected from the bulbous stem of *Phoenix acaulis* Roxb. and eaten with rice, raw or fried in mohwa oil, by the Murias of Bastar state of the former Central Provinces and the tribal people of Kanara. Water beetles (*Dytiscidae* and

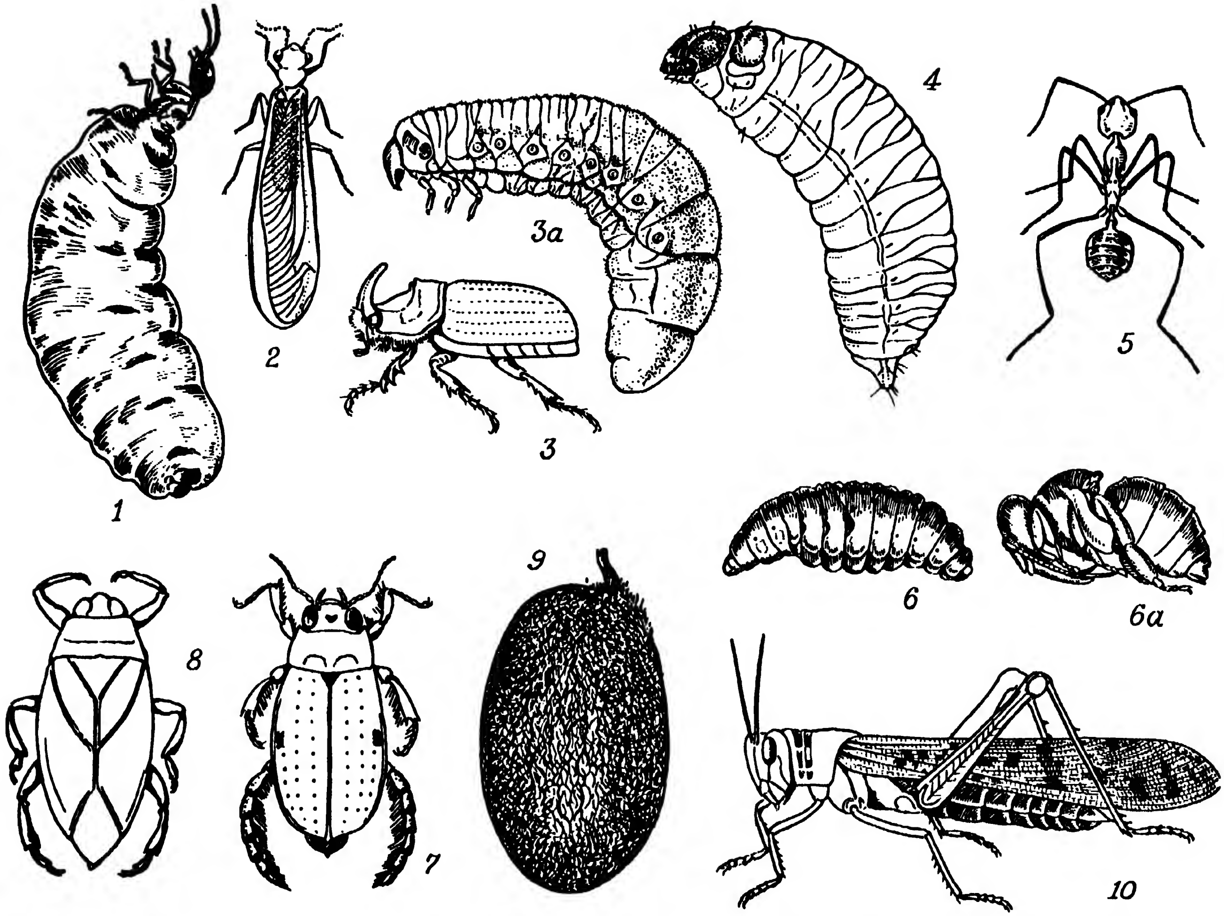



FIG. 130. INSECTS AS FOOD: 1—QUEEN TERMITE 2—WINGED TERMITE (REPRODUCTIVE FORM) (×1½) 3—RHINOCEROS BEETLE (ORYCTES RHINOCEROS LINN.) (APPROX. NAT. SIZE); 3a—LARVA (×2) 4—LARVA OF RED PALM WEEVIL (RHYNCHOPHORUS FERRUGINEUS OLIV.) (×1½) 5—RED ANT (OECOPHYLLA SMARAGDINA FABR.) (×3) 6—LARVA OF HONEY-BEE (×3); 6a—PUPA (×2½) 7—WATER BEETLE (ERETES STICTICUS LINN.) (×2) 8—GIANT WATER BUG (LITHOCERUS INDICUS LEP. & SERV.) (×½) 9—COCOON OF WILD SILK WORM (ANTHERAEA PAPHIA LINN.) 10—DESERT LOCUST (SCHISTOCERCA GREGARIA FORSK.) (NAT. SIZE)

*Hydrophilidae*) are eaten both as medicine and as confection. The adult and immature stages of a water beetle, *Eretes* (*Eunectes*) *sticticus* Linn., commonly found in India are eaten as a delicacy by the Burmese.

A few species of stink bugs (*Pentatomidae*) and water bugs (*Belostomidae*) are eaten in India, China and Siam. One species of *Cicadidae* is also an article of diet among the Siamese.

*Coridius* (*Aspongopus*) *chinensis* (Dallas) (*Pentatomidae*), occurring in Bhutan, Assam and China, is known to be eaten by some tribes in Assam. *Coridius* (*Aspongopus*) *nepalensis* (Westw.) is used as food; pounded with rice, it imparts an aromatic flavour. *Cyclopelta subhimalayensis* Strick. (*Pentatomidae*) is fairly common in Assam and is eaten with rice. *Erthesina fullo* Thunb. (*Pentatomidae*), a species of variable coloration feeding on the trunks of many trees, is widely distributed in India and is eaten by the Nagas in Assam. The giant water bug, *Lithocerus* (*Belostoma*) *indicus* Lep. & Serv. (*Belostomidae*), is widely distributed and is caught by water nets for cooking. Two species of *Sphaerodema* (*Belostomidae*), namely *S. rustica* Fabr. and *S. molestum* Duf., small, flat, greenish water bugs common in India and Siam, are eaten with relish.

Some species of grasshoppers and the locusts, *Patanga succincta* Linn. and *Schistocerca gregaria* Forsk., have been used as food on account of their large size and frequent availability in large numbers since early times. They are roasted and eaten in Africa, Siam and India. They are reported to be rich in proteins.

Among the crickets, *Gryllus testaceous* Wlk.,

*Brachytrypes portentosus* Licht. and *Liogryllus bimaculatus* deG., which live in burrows, are roasted and eaten.

White ants (*Isoptera*) are considered to be rich in fats, proteins, phosphates and potash. According to one analysis, the dried material contains 44.4% fat and 36% protein. Termite queens are roasted or fried in fat and eaten as a delicacy by some tribes in India, Africa, Siam and other countries. At swarming periods, winged termites are caught after the wings drop off, roasted with salt and eaten. They are reported to be dried and sold as food in some parts of Africa.

Termite oil obtained by petroleum ether extraction of fried insects gave the following characteristics: m.p., 40–41° ; $d^{28°}$, 0.906 ; $n_D^{40°}$, 1.461 ; sap. val., 191 ; acid val., 18.6 ; Hehner val., 94.1 ; iod. val., 55.4 ; and unsap. matter, 3.76%. The oil yields a fairly hard soap ; it has no commercial importance.

The red ant, *Oecophylla smaragdina* Fabr. (Order *Hymenoptera*, family *Formicidae*), is found throughout India, Burma, Malaya and Siam. The ants are rusty red, of medium size and live on trees in nests made of leaves bound together with silken threads secreted by the larvae. In Burma and Siam, they are regarded as a delicacy ; made into a paste they are used as a condiment with curry.

The honey, larvae and pupae of the rock-bee, *Apis dorsata* Fabr. (*Apidae*), found in the combs are eaten by various Indian tribes. The honey and grubs of *Apis indica* Fabr. are also eaten.

In some parts of India and China, the pupae of the wild silkworm, *Antheraea paphia* Linn. (*Lepidoptera*), are regarded as a delicacy and eaten after the silk is extracted. They are either cooked in hot water or roasted. This species occurs commonly in Assam, Bengal, Kashmir and other parts of India.

*Other Uses*

Among the more important economic products of insect origin are honey and wax, lac and silk (cf. Wlth India—Raw Materials, I, 166).

Lac is the resinous encrustation of the lac insect, *Laccifer* (*Tachardia*) *lacca* (Kerr). About 80% of the world's production of lac comes from India. Silk originates as a fine thread in the spittle of caterpillars belonging to the *Bombycidae* and the *Saturnidae* families of moths. The mulberry silkworm, *Bombyx mori* Linn., the tassar silkworm, *Antheraea paphia* Linn., and the eri worm, *Attacus ricini* Boisd., yield valuable commercial fibres. The mulberry silkworm yields superior quality of silk. Information on the production, composition and uses of lac and silk will be found under the respective entries.

Very little information is available on the use of insects as medicine in India. Honey-bees, *Apis mellifica* Linn. and *A. indica* Fabr. (*Apidae*), yield nutritious honey used as demulcent and laxative, especially for children, and for application to ulcers. Bees' wax is used as a vehicle for ointments. The eggs of red ants (*Formicidae*) (Sans.—*Pipeelika ;* Hindi—*Chintee ;* Tam.—*Erumbu ;* Tel.—*Cheema ;* Kan.—*Iruve*) form a constituent of a medicine used for malaria by some tribes.

The chrysalis or the silk pod of the mulberry silkworm, *Bombyx mori* Linn. (*Bombycidae*) (Bengal—*Pat ;* Bombay—*Reshammapotan ;* Madras—*Putloo puchie*), is used as styptic, tonic and astringent ; it is believed to check profuse menstruation, leucorrhoea and chronic diarrhoea.

The cochineal insect, *Dactylopius coccus* Costa syn. *Coccus cacti* Linn. (Hindi—*Bearboughtee ;* Bombay—*Kiramaza ;* Madras—*Cochinil puchi*), possesses sedative, aphrodisiac and antiseptic properties, and is used in neuralgia and whooping cough. The insects contain carmine or carminic acid, coccerin, myrestin, fat and fatty acids. The stink bug, *Coridius* (*Aspongopus*) *chinensis* (Dallas), is used as an aphrodisiac in China. Termite queen (Hindi—*Shah deemak*) is believed to be a powerful sexual tonic. Bites of katydids or crickets are reported to remove warts.

The mylabris beetle, *Mylabris chicorii* (Linn.) (*Meloidae*) (Hindi—*Telenimakhi ;* Madras—*Puistaninai*), and other species of *Mylabris* are used as a substitute for cantharides. It acts as an internal stimulant and diuretic ; it is used externally as counter-irritant and vesicant. The water beetles (*Dytiscidae* and *Hydrophilidae*) are reported to be anti-diuretic.

Very few insects are known to yield dyes. Until the aniline dyes came into the market, cochineal insects were used as the source of a beautiful carmine-red pigment. The lac dye obtained by extracting crushed stick lac in water was once used extensively for colouring silk, wool and leather. It is obtained as dark purplish cakes from lac washeries and it is still in use, in some parts of India, for dyeing silk and wool. The cakes contain: moisture, 9–11 ; colouring matter, 10–13 ; and ash, 15–18%. The colouring matter, laccaic acid, crystallises in rhombic plates of yellowish red colour, and is soluble in alcohol, acetone and acetic acid. With alkalis, it produces a

characteristic red coloration. Dyed fabrics are fast to perspiration. The dye is used also for decorative painting of hands and feet by ladies.

Certain galls, especially oak galls, produced by some insects, are used as a source of dye and tannin in ink manufacture. Bright iridescent elytra of some buprestid beetles are used in ornaments.

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## INULA Linn. (*Compositae*)

A genus of herbs, rarely shrubs, distributed in Europe, Africa and Asia, mostly in temperate regions. About 20 species occur in India.

**I. racemosa** Hook. f.

D.E.P., IV, 474; Fl. Br. Ind., III, 292; Kirt. & Basu, Pl. 527.

KASHMIR—*Poshkar*.

A stout herb, up to 5 ft. tall, found in north-western Himalayas at altitudes of 5,000–14,000 ft. Leaves leathery, rough above, densely hairy beneath, toothed: radical leaves 8–18 in. × 5–8 in., long-stalked, elliptic-lanceolate: cauline leaves ovate-oblong, semi-amplexicaul, often deeply lobed at the base; flower-heads many, 1.5–2.0 in. diam., yellow, in racemes; achenes c. 1/6 in. long, slender, with reddish pappus.

Fresh roots of *I. racemosa* have a strong aromatic odour resembling orris and camphor; dried roots have a weak odour. They are used in Kashmir as adulterant of *Kuth* (roots of *Saussurea lappa* C. B. Clarke). They contain inulin (10.0%) and an essential oil (1.3%) containing alantolactone ($C_{15}H_{20}O_2$: m.p., 76°). Alantolactone is the chief constituent of the oil obtained from the European species *I. helenium* Linn.; it possesses strong anthelmintic properties and is more potent and less toxic than santonin. Alantolactone in 1:1,000 dilution kills *Ascaris* in 16 hr. while santonin in the same dilution requires more than 2 days. It has been used as an anthelmintic for children (dosage, 0.009–0.2 g.). Alantolactone is also antiseptic, expectorant and diuretic. The seeds are bitter and aphrodisiac (Kirt. & Basu, II, 1352;

*Indian For.*, 1937, **63,** 414 ; Kapoor *et al., J. sci. industr. Res.*, 1953, **12A,** 311 ; U.S.D., 1955, 1723 ; *Chem. Abstr.*, 1937, **31,** 1878 ; Guenther, V, 456).

**I. royleana** DC.

D.E.P., IV, 474 : Fl. Br. Ind., III, 292 : Blatter, I, Pl. 29, Fig. 3.

KASHMIR—*Zahelnülkohee.*

A stout herb, up to 2 ft. high, found in north-western Himalayas at altitudes of 7,000–11,000 ft. Leaves rather membranous, pubescent, finely toothed: radical leaves 6–10 in. × 4·6 in., ovate-oblong, with winged petioles: cauline leaves variable, lyrate ; flowerheads 3–6 in. diam., orange-yellow, solitary on stout, hairy peduncle: achenes *c.* 1/6 in. long, slender, with pale red pappus.

The plant is considered to be poisonous. It is used as a disinfectant and parasiticide, particularly against lice, fleas and ticks. The roots are used as an adulterant of *Kuth ;* they yield an essential oil containing alantolactone. They also contain inulin (10.1%), two alkaloids, namely roylene ($C_{21}H_{35}O_6N$ ; m.p., 120–21°; yield, 3%) and inuline ($C_{16}H_{23}O_4N$ : m.p., 165° decomp.), and small amounts of oleoresinous matter, tannins and colouring matter. Roylene is non-toxic to ciliates and shows no antibacterial activity. It produces a fall in blood pressure and stimulates the tone and rhythmic movement of intestines when administered intravenously to urethainized animals (Kirt. & Basu, II, 1353 ; Chopra, *J. sci. industr. Res.*, 1952, **11A,** 239 ; *Indian For.*, 1937, **63,** 414 ; Chopra *et al., Indian J. med. Res.*, 1945, **33,** 139 ; Chatterjee & Talapatra, *Proc. Indian Sci. Congr.*, 1957, pt III, 124).

*I. grandiflora* Willd. is a stout herb, up to 1.5 ft. tall, found from Kashmir to Nepal at altitudes of 6,000–12,000 ft. Its roots are aromatic and are reported to be used in Kashmir as adulterant of *Kuth* (Coventry, II, 54).

*I. grantioides* Boiss. is a shrubby perennial up to 2 ft. high, found in Kutch. It is reported to be used for asthma (Kirt. & Basu, II, 1353).

*I. graveolens* Desf. is a slender, much-branched herb, found in West Pakistan. It is reported to possess diuretic properties and used in calculus diseases. The plant contains a volatile oil (Kirt. & Basu, II, 1352 ; Wehmer, II, 1218).

**Ionidium** — *see* **Hybanthus**

**Ipecac, Ipecacuanha** — *see* **Cephaelis**

**IPHIGENIA** Kunth (*Liliaceae*)

D.E.P., IV, 476 ; Fl. Br. Ind., VI, 357.

A genus of herbs distributed in Africa, south-east Asia and Australasia. Three species occur in India.

*I. indica* Kunth (TAM.—*Nirpanai ;* SANTAL.—*Chutia chandbol*) is an erect herb, *c.* 1 ft. high, found throughout India up to an altitude of 7,000 ft. in the Himalayas. Corm globose, 0.4–0.75 inch in diam., tunicate with pale brown sheaths ; leaves few, sessile, linear, 6–8 in. long, finely pointed, lower leaves larger ; flowers reddish or purple, solitary or corymbose ; capsule oblong, ¼–¾ in. long, 3-valved ; seeds brown, globular.

The flowers are said to yield a red dye. In parts of Bihar, the corms are used for colic and headache (Bressers, 143).

**IPOMOEA** Linn. (*Convolvulaceae*)

A large genus of twining, creeping, floating or erect herbs, rarely shrubs or trees, widely distributed throughout the tropical and warm temperate regions of the world. About 50 species are found in India, the most important being *I. batatas* (sweet potato) extensively cultivated for its edible root tubers. A number of species have been introduced into India and many species are grown in gardens for ornamental purposes ; some are of medicinal value.

**I. aquatica** Forsk. syn. *I. reptans* Poir. SWAMP CABBAGE

D.E.P., IV, 476 ; III, 415 ; C.P., 686 ; Fl. Br. Ind., IV, 210 ; Fl. Malesiana, Ser. I, **4**(4), 473.

HINDI—*Kalmisag, karmi, patuasag ;* BENG.—*Kalmisak ;* MAR.—*Nadishaka ;* GUJ.—*Nalanibhaji ;* TEL.—*Tutikura ;* TAM.—*Vellaikeerai.*

PUNJAB *Ganthian, nali, nari ;* DELHI *Sarnali, nali.*

An aquatic, trailing or floating, herbaceous perennial, sometimes annual, with long, hollow stem rooting at the nodes, found throughout India. Leaves elliptic or ovate-oblong, cordate or hastate at the base ; flowers infundibuliform, 2.5–5 cm. long, white or pale purple with dark purple eye, solitary or in five-flowered cymes ; fruit a capsule, 0.8 cm. long, ovoid, smooth ; seeds 2–4, densely pubescent.

*I. aquatica* is found trailing on moist soil or mud along the margins of stagnant streams, fresh water ponds, ditches, marshes and wet rice fields ; it is sometimes found floating on water surfaces. It occurs both wild and cultivated and is easily propagated by

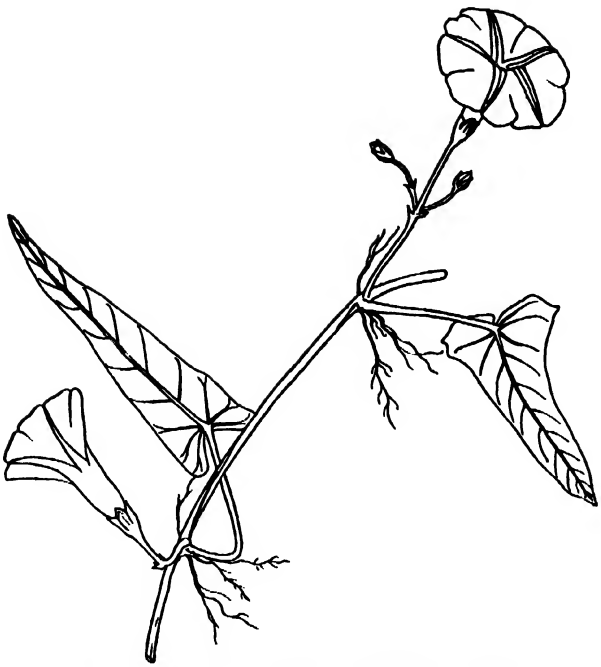


FIG. 131. IPOMOEA AQUATICA—FLOWERING BRANCH

cuttings; it grows rapidly producing dense masses of foliage within a few weeks of planting.

The young terminal shoots and leaves are used as vegetable and in salad. Analysis of fresh leaves gave the following values: moisture, 90.3; protein, 2.9; fat (ether extr.), 0.4; carbohydrate, 4.3; mineral matter, 2.1; calcium, 0.11; and phosphorus, 0.05%; iron, 3.9 mg.; carotene (vit. A), 3,300 i.u.; vitamin $B_1$, 87 $\mu$g.; nicotinic acid, 0.6 mg.; riboflavin, 120 $\mu$g; vitamin C, 137 mg./100 g. They also contain vitamin E, 11.8 mg./100 g. The leaves are a good source of minerals and vitamins, especially carotene. The carotenoids present include $\beta$-carotene, xanthophyll and traces of taraxanthin. Sodium, potassium, magnesium, copper, manganese, silica and iodine (1526 $\mu$g./kg. of dry leaves) are present in the ash which is alkaline in reaction. Hentriacontane, sitosterol, sitosterol glucoside, and a higher alcohol (m.p., 267°) have been separated from the lipoids. Pectin content of the whole plant is 0.76% [Intengan *et al.*, *Philipp. J. Sci.*, 1954, **83**, 193; *Hlth Bull.*, No. 23, 1951, 32; Basu & Goswami, *Sci. & Cult.*, 1938–39, **4**, 299; *Chem. Abstr.*, 1947, **41**, 5643; 1935, **29**, 3376; 1948, **42**, 2691; Scharpenseel & Vicario, *Araneta J. Agric.*, 1956, **3**(4), 56].

The plant serves as a green fodder of high nutritive value. It is relished by cattle and pigs, and produces no ill effects. It is also used as fish food. The roots are eaten by wart-hogs; they taste sweet and are eaten in times of scarcity. Analysis of fresh leaves and stems gave the following values: moisture, 92.5; protein, 2.1; fat, 0.2; carbohydrates, 2.9; fibre, 0.9; ash, 1.4; calcium (CaO), 0.13; and phosphorus ($P_2O_5$), 0.07%; *digestible nutrients:* protein, 1.8; fat, 0.1; carbohydrates, 2.8; and fibre, 0.8%; nutritive ratio, 2.1; and starch equivalent, 5.5 lb./100 lb. The whole plant contains (dry basis): dry matter, 6.9; protein, 19.6; fat, 3.4; carbohydrates, 41.1; fibre, 20.4; and ash, 15.5% (Payne, *Trop. Agriculture, Trin.*, 1956, **33,** 302; Dalziel, 439; Teik, *Sci. Ser. Dep. Agric. Malaya*, No. 24, 1951, 68, 77).

The juice of the plant is used as an emetic in cases of opium and arsenical poisoning. Dried juice has purgative properties. Leaves and stems are said to be cooling. In Assam, the plant is given for nervous and general debility. It is used also for piles. In Cambodia, the plant is applied as a poultice in febrile delirium. The buds are used in the treatment of ringworm (Kirt. & Basu, III, 1724; Burkill, II, 1250).

**I. batatas** (Linn.) Lam. SWEET POTATO

D.E.P., IV, 478; III, 415; C.P., 687; Fl. Br. Ind., IV, 202; Fl. Malesiana, Ser. I, **4**(4), 469.

HINDI—*Mitha alu, shakarkand*; BENG.—*Lal alu, ranga alu*; MAR.—*Ratalu*; GUJ.—*Kanangi, sakaria*; TEL. *Chelagada;* TAM.—*Sakkareivelleikilangu;* MAL.—*Chakarakilangu*; KAN.—*Genasu*; ORIYA—*Kanda*.

PUNJAB—*Shakarkandi*; SANTAL—*Sakarkenda*.

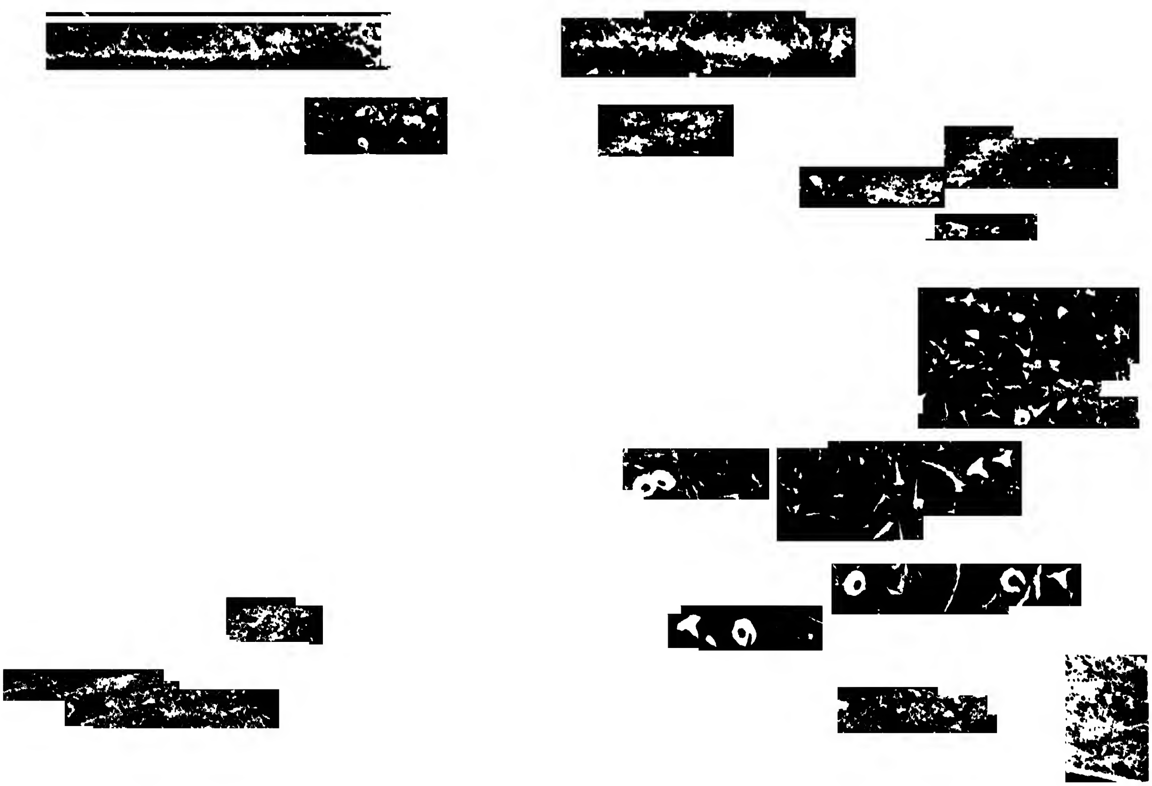
A slender, prostrate, trailing or ascending perennial herbaceous vine, producing succulent, tuberous roots. Leaves alternate, variable, ovate-cordate, 2.5–8.75 cm. long, entire, angular or deeply lobed; flowers solitary or cymose, 5 cm. long, funnel-shaped, white or purple; capsules globose or ovoid, brownish in colour; seeds 2–4, small, black, somewhat flattened.

The origin of sweet potato is still a matter of conjecture as most of the known wild species of *Ipomoea* differ greatly from the cultivated plants. The cytological make-up of sweet potato also suggests the complexity of its origin. It is believed by some workers that sweet potato originated from *I. tiliacea* (Willd.) Choisy, a wild species growing in tropical America (Cooley, *Sci. Mon., N.Y.*, 1951, **72,** 325; Thompson, 414).

Sweet potato is considered to be a hexaploid with 90 somatic chromosomes. It is of comparatively recent origin derived by amphidiploidy of a tetraploid (2n=60) and a diploid (2n=30) species The plant does not generally produce flowers; even

if it does, seeds are rarely set. The high degree of self incompatibility and failure to produce seeds make breeding of new strains difficult. Sweet potato improvement was, until recently, confined to the selection of new types which arose as somatic mutations and asexual propagation was followed. It has now been found that flowering and seed formation in sweet potato can be induced by various treatments and improvement of the crop by hybridisation has thus been possible. The treatments include girdling, overwintering, training vines on trellis, controlling exposure to day light, foliar application of 2, 4-D and grafting on root-stocks of closely related ornamental species without tuberous roots, e.g. *I. purpurea*, *I. carnea*, *I. ruber*, *Quamoclit sloteri* and *Calonyction aculeatum* [Kehr & Ting, *Genetics*, 1953, **38,** 672; Thompson, 428; Richharia & Ghosh, *Indian J. Hort.*, 1954, **11,** 33; Miller, *J. Hered.*, 1937, **28,** 347; 1939, **30,** 485; Kehr *et al.*, *Proc. Amer. Soc. hort. Sci.*, 1953, **62,** 437; Zobel & Hanna, *Calif. Agric.*, 1953, **7**(7), 13; Howell & Wittwer, *Science*, 1954, **120,** 717].

Under conditions of induced flowering, many of the flowers are sterile, and only a few seeds are produced under special cultural treatments. Marked sterility of flowers is attributed to high polyploidy and the low percentage of seed formation, to cytological abnormality in meiosis of anthers which leads to incompatibility in the process of fertilisation. The types which are self-incompatible are compatible with other types. Self-sterile types will set seed when grown in close proximity to other types or when artificially pollinated. Thus production of new strains has, in recent years, been effected by means of seedlings raised from seeds which have naturally set or from seeds obtained by controlled cross pollination. In India, breeding work on sweet potato has been carried out in several places, and the technique of training vines to trellis is adopted to induce flowering (Thompson, 428; Abraham, *Indian J. Genet.*, 1957, **17,** 212; Rao, *Curr. Sci.*, 1947, **16,** 156; *Plant Breed. Abstr.*, 1954, **24,** 35; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 204; Miller, *J. Hered.*,



*Dep. Agric., Mysore*

FIG. 132. IPOMOEA BATATAS—SEEDLINGS UNDER MULTIPLICATION

1939, **30,** 485; Sampath & Bhanumurty, *Madras agric. J.*, 1948, **35,** 72; Chatterjee & Nag Biswas, *J. Indian bot. Soc.*, 1952, **31,** 352).

Sweet potato is widely grown throughout the tropical and some parts of temperate regions in Africa, India, China, Japan, Malay Archipelago, the Pacific Islands, tropical America and southern United States. In India, it is grown in practically all the States and ranks third in importance among tuber crops, exceeded by potato (6 lakh acres) and tapioca or cassava (5 lakh acres). The area under sweet potato cultivation is about 4 lakh acres, the major areas being Bihar and Uttar Pradesh, followed by Mysore, Kerala, Bombay, Orissa, Madras and Madhya Pradesh. Bihar and Uttar Pradesh together account for nearly 60% of the total area. Table 1 summarises the acreage and production of sweet potato in the principal States of India.

Sweet potato is cultivated in most of the districts in Bihar. In other States, the principal areas of cultivation are: Sultanpur, Etah, Pratapgarh, Badaun, Farukhabad, Allahabad, Basti, Shahjahanpur and Gonda districts in U.P.; the sub-montane and central districts in Punjab; Midnapur, Hooghly, Murshidabad, Howrah, 24-Parganas and Nadia districts in West Bengal; Tiruchirapalli, S. Arcot, N. Arcot, Madurai, Tirunelveli and Chinglepet districts in Madras; Visakhapatnam, Srikakulam, Cuddapah, Chittoor and West Godavari districts in Andhra Pradesh; S. Satara, N. Satara, Sholapur, Poona, Nasik, Kaira, Thana, Kolaba, W. Khandesh and Ahmednagar districts in Bombay; Belgaum, Bijapur, Kanara, Hassan, Chikmagalur, Bangalore and Kolar districts in Mysore; and Malabar in Kerala.

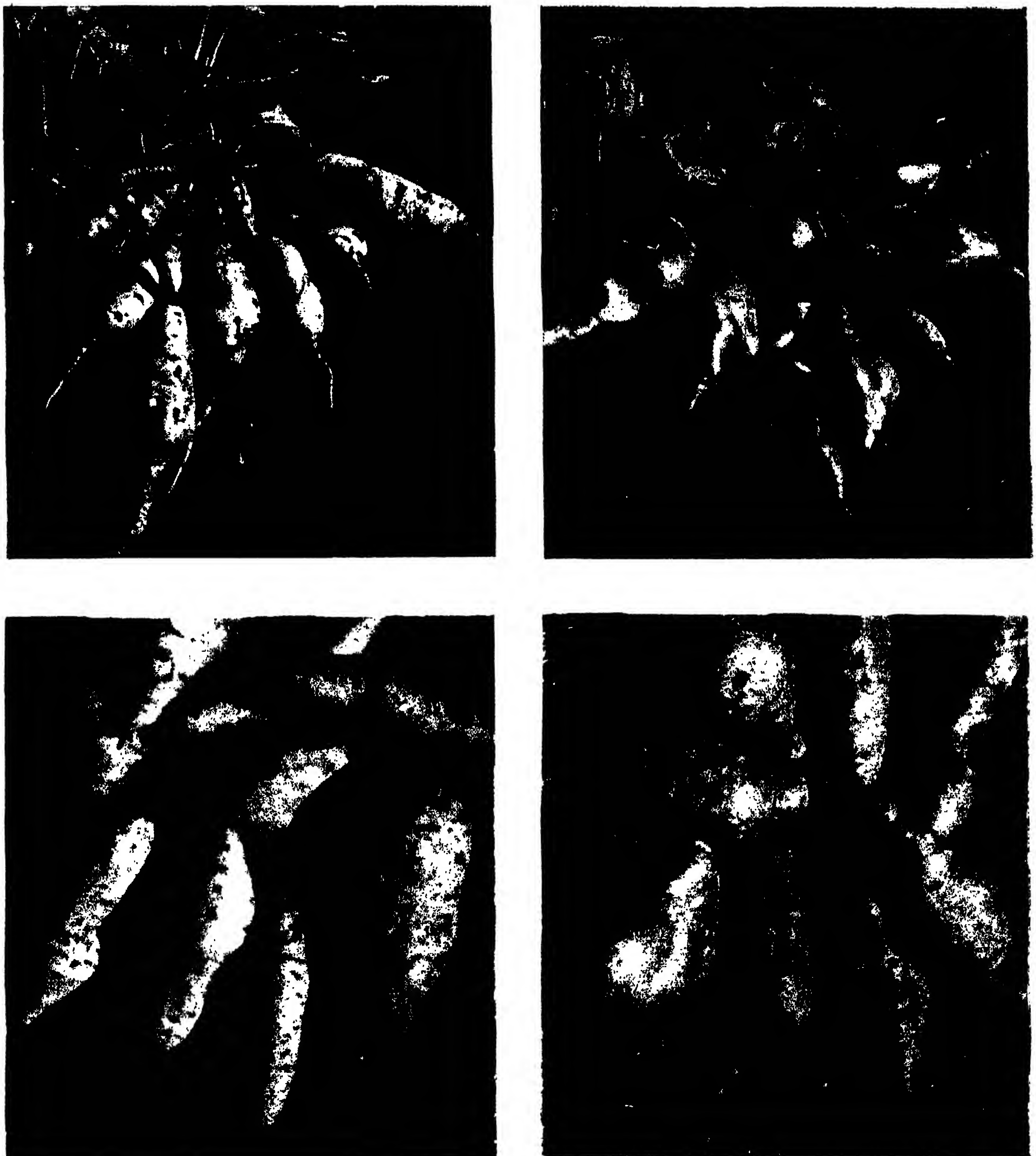
The tubers are produced close to the base of the main stem or at nodes of trailing vines that rest on the ground. Tubers may be of bunched habit when close to the stem or they may be borne on laterals. A plant produces 40–50 tubers of various sizes. The length may vary from a few inches to a foot: they may be spindle-shaped or almost spherical. The surface may be smooth and uniform or it may be irregularly ribbed; the colour of the skin may be white, creamy, yellow, brown, golden, bronze, red, purple and pinkish and the colour of flesh may also vary from white through shades of yellow to red and purple. The weight of a single tuber varies from a few ounces to 2 lb. or more; in rich soil tubers 3 to 12 lb. in weight have been raised (Cobley, 173; Hector, II, 948–49; Mudaliar, *Madras agric. J.*, 1950, **37,** 421; Nicholls & Holland, 450).

In America, attempts have been made to classify sweet potato types, on the basis of morphological characters, into eight major groups. The types are further divided, according to cooking characteristics, into those which give a dry mealy flesh and those which give a soft, moist, sweet flesh when cooked; the latter are often erroneously called yams.

**TABLE 1—ACREAGE AND PRODUCTION OF SWEET POTATO IN INDIA***

| States | Area (1,000 acres) | | | | | Production (1,000 tons) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 | 1951–52 | 1952–53 | 1953–54 | 1954–55 | 1955–56 |
| Bihar | 218 | 187 | 162 | 180 | 128 | 411 | 303 | 347 | 435 | 271 |
| Uttar Pradesh | 77 | 77 | 102 | 138 | 105 | 378 | 207 | 518 | 671 | 500 |
| Mysore | 27 | 29 | 28 | 28 | 29 | 108 | 116 | 111 | 118 | 119 |
| Kerala | 13 | 13 | 14 | 26 | 22 | 38 | 38 | 36 | 59 | 55 |
| Bombay | 20 | 20 | 21 | 21 | 21 | 63 | 72 | 72 | 85 | 106 |
| Orissa | 18 | 27 | 27 | 20 | 20 | 16 | 33 | 33 | 8 | 8 |
| Madras | 19 | 9 | 22 | 14 | 16 | 68 | 32 | 82 | 56 | 63 |
| Madhya Pradesh | 15 | 12 | 14 | 15 | 15 | 34 | 27 | 30 | 32 | 31 |
| Assam | 6 | 15 | 11 | 13 | 14 | 10 | 20 | 15 | 18 | 19 |
| Andhra Pradesh | 9 | 8 | 8 | 9 | 7 | 33 | 30 | 28 | 35 | 25 |
| West Bengal | 6 | 6 | 7 | 7 | 7 | 24 | 24 | 25 | 25 | 25 |
| Others | 3 | 4 | 5 | 6 | 5 | 5 | 9 | 11 | 11 | 9 |
| Total | 431 | 407 | 421 | 477 | 389 | 1,188 | 911 | 1,308 | 1,553 | 1,231 |

* *Area & Prod. Minor (Non-forecast) Crops in Reorganised States* (1949/50–1955/56), *Directorate Econ. & Statist., Govt. of India*, 1957, 6, 7.



*Bot. Div., I.A.R.I., New Delhi*

PUSA SUFFAID PUSA LAL

IPOMOEA BATATAS — WHITE AND RED SKINNED TYPES

Important among the commercial types are: Yellow Jersey, Big-stem Jersey, Triumph and Gold Skin with mealy flesh and Nancy Hall, Puerto Rico, Dooley and Pumpkin Yam with soft flesh. Types Pelican Processor and Whitestar have been isolated for the production of sweet potato starch (Thompson, 422–27; Boswell, *Fmrs' Bull. U.S. Dep Agric.*, No. 2020, 1950).

Sweet potatoes cultivated in India may be grouped under two main types broadly distinguished by the colour of the tuber coat; they are the white-skinned types and the red-skinned types, the colour of flesh being white in both; a type with brownish skin is sometimes met with. Tubers of the red type are generally smaller in size than those of the white type which are also more uniform in shape and possess better keeping quality. The red type is sweeter and less fibrous or stringy than the white one. In North India, the red type is preferred, while in S. India the white type is favoured (Mollison, III, 193; Patel, *Poona agric. Coll. Mag.*, 1950–51, **41,** 120; *Farm News Release, Indian Coun. agric. Res.*, No. 64).

A few types from China and America have been obtained and selections from them are recommended for cultivation. *Pusa Suffaid* (also known as *V.2*) is a white-skinned and white-fleshed, high yielding selection from a Chinese type, *F.A. 17 White*. It bears elongated tubers which keep well under storage; the flesh after cooking is creamy white in colour, sweet, non-fibrous and very palatable. *Pusa Suffaid* is suitable for growing in the Punjab, Rajasthan, Uttar Pradesh, Bihar, Bombay, Mysore and Madras. *V.12*, a Chinese type (*Tie Shin Tun*) grown in Madras and west coast yields large, elongated and white-skinned tubers with light purple shade towards the centre. *V.6* obtained from a Chinese type, *F.A. 17 Red*, and grown in the Punjab, yields long, thick, red tubers with non-fibrous flesh. *Pusa Sunehri*, a selection from an American complex cross (Porto Blanco × Waanop) × Australian Canner, yields elongated tubers with light brown skin and yellow flesh; cooked flesh is orange yellow, moist, sweet and palatable; it is not as high a yielder as *Pusa Suffaid*. *B. 4004*, an American type selected in Bombay, bears long, thick, spindle-shaped, white-skinned tubers with red or light purple streaks at both ends; the flesh is cream-coloured. It is high yielding and early maturing. It is also grown in the Punjab, Madras and west coast under the name *F.B. 4004* or *V. 8*. In the Punjab, *V. 13* isolated from an American type *B. 219*, produces medium-sized, spindle-shaped, red-skinned tubers, the flesh of which is fibrous. In Bihar, two American types, *Ranger* and *B. 5941*, have been selected. *Ranger* yields long, thick tubers with purple skin and light yellow flesh. It is sweeter than any of the Indian varieties. *B. 5941* has long tubers bulging at the centre with purple skin and light orange-coloured flesh. Both are high yielders and rich in sugar and carotene. High yielding types isolated in Mysore are *Deenabandhu, Sojiga, Raja* and *Kiribatala*, the last one being of Ceylonese origin. A large number of high yielding strains have been evolved in Kerala [Singh & Bhagchandani, *Indian Fmg, N.S.*, 1955-56, **5**(6), 26; Chavan & Apte, ibid., 1954-55, **4**(10), 7; Purewal & Singh, *Punjab Fmr*, 1953, **5**(1), 11; *Annu. Rep. Indian Coun. agric. Res.*, 1953–54, 51–52; Ail, *Indian Fmg, N.S.*, 1956–57, **6**(5), 23; Singh & Ghosh, ibid., 1955-56, **5**(8), 23; Iyengar & Doraswami, *Mysore agric. J.*, 1951, **27,** 29; private communication from Prof. Abraham, Trivandrum].

### CULTIVATION

*Climate and Soil*—Sweet potato requires a warm, moist and long growing season; humidity should be low when the crop approaches maturity. It grows best where the mean temperature is above 72°F. It is sensitive to frost but it can withstand drought. A well-distributed, fairly low to moderate rainfall (30–50 in. anually) is necessary for growth. In areas of high rainfall, the crop is grown towards the close of the wet season, and in areas of low rainfall, irrigation is required. Sweet potato can be grown on a variety of soils, but it is best adapted to friable well-drained sandy loam (*p*H, 5.0–6.8) with clayey subsoil. It does well on light sandy soils, lightly manured. Good drainage is essential. Heavy and rich soils tend to produce excessive vine growth at the expense of tuber formation; tubers of vines growing in rich soils are likely to be rough and irregular in shape. In areas which are not suitable for other vegetable crops or on new land sweet potato can give good yields. It can be grown also in dry river beds (Thompson, 414–15; Purewal, 81; Mollison, III, 193–94; Boswell, loc. cit.; Work, 317).

*Preparation of land*—The land should be repeatedly ploughed and harrowed to a depth of about 6 in. and brought to a fine tilth; deeper ploughing is not recommended as it results in long slender tubers. After ploughing, beds are prepared for planting, and where rainfall is heavy or the soils drain poorly, ridges 10–14 in. high are thrown up. Sweet potato is a heavy feeder and depletes the soil nutrients

rapidly and should not be grown too often in the same area; the crop does not follow any particular rotation but it is advisable to raise other crops in the area for three or four years before it is again planted (Boswell, loc. cit.; Purewal, 81).

*Manuring*—Sweet potato responds to good soil management and manurial treatment. In heavy fertile soils, manure is not usually applied. In less fertile or poor soils, farmyard manure is given at the rate of 5-20 tons per acre; cattle are sometimes penned in the field. In the west coast districts of Malabar and S. Kanara, wood ash, fish guano, tobacco stems and green leaves are applied as manure. When sweet potato follows a previously manured crop, no other manure need be applied; thus in Madras, it is not usual to apply any manure as the crop generally follows heavily manured ragi (*Eleusine coracana*). Application of 500 lb. of bone meal or 650 lb. of a mixture containing 2 parts bone meal, 4 parts groundnut cake and 1 part of potassium sulphate per acre is reported to have given good results. Top dressing at the rate of 60 lb. of ammonium sulphate gives a higher yield of tubers. On light sandy soils, a dressing of 300 lb. of superphosphate and 100 lb. of ammonium sulphate per acre is given. Fertilizers are worked into the rows on ridges or in flat beds where cuttings are to be set. Green manuring has also proved beneficial [Mudaliar, loc. cit.; Patel, *Poona agric. Coll. Mag.*, 1950-51, **41**, 120; Singh & Bhagchandani, loc. cit.; Chaugule & Sendage, *Farmer*, 1958, **9**(5), 21].

In America, high yields have been reported from areas receiving application of 1,000-1,500 lb. of fertilizer (N, 2-4%; $P_2O_5$, 2%; and $K_2O$, 8-10%) per acre. The quantity of nitrogenous fertilizer is reduced in the case of soils treated with green manure or animal manures. Good response to the application of potash is obtained from light sandy soils. The fertilizer is applied in two stages: a part of it is worked into ridges about 2 weeks before planting; the rest is applied as a top dressing to the sides 2-3 weeks after planting (Boswell, loc. cit.).

*Propagation*—Though a perennial, the crop is treated as an annual under cultivation. It is grown as a summer crop in the sub-tropical plains and on the lower hills of northern India. Two crops are usually raised in parts of Bihar and Bengal, one in August-September and the other in December-January, both under rainfed conditions. In South India, sweet potato is grown in more than one season; in the districts of Visakhapatnam (Andhra), Malabar and S. Kanara, the crop is grown during the south-west monsoon (planting in June); a second crop is raised in Visakhapatnam district during the north-east monsoon (planting in September). As an irrigated crop, it is grown throughout South India in September-November or even later. In Nilgiris, the crop is fed by pre-monsoon rains (April-May). In areas of heavy rainfall in western ghats, it is grown on terraces [Singh & Bhagchandani, loc. cit.; Mudaliar, loc. cit.; Mollison, III, 194; *Indian hort. Abstr.*, 1954, **4**(7), 12].

Sweet potato may be propagated by seeds; the seedlings produced are very variable and propagation by seed has been used mostly for selection work. The seeds have a hard coat and germination takes a long time, unless the seeds are pre-treated. The seed coat may be scarified or seeds soaked in conc. sulphuric acid (sp. gr., 1.84) for 20 minutes and washed in warm water before sowing; better results are obtained by increasing the soaking period to 45-60 minutes and notching the coat with an emery grinding wheel (Hector, II, 960; Venkataratnam & Satyanarayanamurthy, *Curr. Sci.*, 1953, **22**, 29; Martin, *Proc. Amer. Soc. hort. Sci.*, 1946, **47**, 387).

For raising crops sweet potato is propagated vegetatively by vine cuttings obtained from the previous year's crop or by sprouts raised from tubers. Propagation by cuttings is favoured as it is cheaper, free from soil-borne diseases, and the tubers produced are of uniform size and shape. The planting material is obtained from a nursery, in which cuttings from fairly mature portions of stems have been previously planted 9-12 in. apart. The nursery is irrigated once in 4-7 days in the early stages and at longer intervals afterwards. The cuttings take root readily and the bed is covered with trailing vines in 2-3 months. Cuttings from vines in the primary nursery are replanted once or twice to get sufficient planting material (Thompson, 418; Boswell, loc. cit.; Mollison, III, 194; Mudaliar, loc. cit.; Chandrasekharan & Sundararaj, *Madras agric. J.*, 1949, **36**, 134).

For raising planting material from tubers, selected tubers are planted in a nursery. The beds are thoroughly prepared and manured; sometimes ammonium sulphate is applied. Tubers are placed 2-3 in. deep in the soil and beds are lightly watered. Each tuber produces a number of sprouts, also called slips or draws. The sprouts grow to a length of 9-12 inches in 4-6 weeks, when they are pulled out and transplanted in the field on ridges 3 ft. apart, the distance between plantings being 1-1½ ft. Two

or more crops of slips are collected from the nursery for planting. Slip planting is the usual method of propagation adopted in America. In India, the practice is different; slips are allowed to run into vines in the nursery and cuttings are taken from the vines for planting [Singh & Bhagchandani, loc. cit.; Mudaliar, loc. cit.; Doraswami & Iyengar, *Mysore agric. J.*, 1945, **23**, 129; Bailey, 1947, II, 3290; Chandrasekharan & Sundararaj, loc. cit.; Purewal & Singh, *Punjab Fmr*, 1953, **5**(1), 11].

The vine cuttings, 1–1½ ft. long, with 3–4 nodes are planted on ridges or in flat beds in loose moist soil. The ridge method of planting is preferred. The ridges are spaced 2–2½ ft. apart, the distance between plantings on the ridge being 9–12 in. The cuttings are set on both sides of the ridges half way on the slope. The central part of the cuttings is buried deep into the wet soil leaving the two ends, with one node on each side, exposed. When planted in flat beds, a spacing of 9–12 in. between cuttings is allowed, the distance between rows being 1½ ft. The rate of planting material per acre varies from 15,000 to 30,000 according to type grown, nature of soil, method of planting and the spacing between cuttings (Mollison, III, 194–95; Mudaliar, loc. cit.; Singh & Bhagchandani, loc. cit.; Patel, loc. cit.).

*Cultural operations*—Once the crop is established, no further cultivation is needed; the field requires weeding in the early stages. During dry weather, 8–20 irrigations are applied between transplanting and harvesting. Trailing vines tend to strike roots at points where nodes come into contact with moist soil, which later develop into small thin tubers, thereby adversely affecting the development of the main tubers. To obviate this, vines are periodically turned over to disturb the root development at contact points. Ridges are earthed up during the growing season to maintain their height and shape (Mollison, III, 196; Mudaliar, loc. cit.; Singh & Bhagchandani, loc. cit.).

*Diseases and Pests*—The fungal diseases affecting sweet potato in India are of minor importance. They include leaf spot caused by *Cercospora batatae* Zimm., white blister caused by *Cystopus ipomoeae-panduratae* (Schw.) Steven & Swing., and black rot caused by *Rhizoctonia solani* Kuhn (*Indian J. agric. Sci.*, 1950, **20**, 107).

The only serious pest of sweet potato reported in India is the weevil (*Cylas formicarius* Fb.). The grub bores tunnels into vines and tubers in the field and also tubers in storage. Infested vines die and dirty patches appear on the surface of affected tubers. Weevil incidence is reduced by adopting plant sanitation methods, such as using only uninfested and disinfected material for planting, practice of crop rotation and destruction of infested vines and tubers; cleaning the field after harvest; earthing up of rows or ridges before tuber formation; application of 2% DDT dust in nursery beds and furrows before planting and also dusting the crop frequently. Vine cuttings, before planting, may be dipped in tobacco decoction or 2% DDT solution, or exposed to Gammexane fumes; elimination of *Convolvulus* spp. which act as alternate hosts for the weevils from the field is recommended. Spraying of crop with Parathion and Dieldrin, three times a month, has proved effective in controlling weevils; applications of Gammexane and Hexyclan (BHC group) have also given good results. Fumigation of storage houses with methyl bromide at the rate of 1 lb. per 1,000 cu. ft. for 4 hr. destroys the pest; infested tubers should be destroyed and the rest fumigated (Ramakrishna Ayyar, 260–62; Trehan & Bagal, *Curr. Sci.*, 1949, **18**, 126; Mudaliar, loc. cit.; *Farm News Release, Indian Coun. agric. Res.*, No. 180, 1956; Satpathy, *Sci. & Cult.*, 1955–56, **21**, 688; Ananthanarayanan & Subramanian, *Madras agric. J.*, 1958, **45**, 74; *Mem. Dep. Agric. Madras*, No. 36, 1954, 950).

Minor insect pests of sweet potato are vine borer (*Omphisa anastomosalis* D.); leaf beetles (*Aspidomorpha miliaris* F., *Metriona circumdata* H., *Chiridia sernotata* B. and *Oncocephala tuberculata* O.); and leaf caterpillars (*Herse convolvuli* L., *Catephia inquieta* W., *Brachmea effera* M., *Junonia orthyia* L., *Euchromia polymena* L. and *Diacrisia obliqua* W.). A scolytid beetle (*Stephanoderes* sp.) has been recorded from Coimbatore in stored tubers. Field rats, white ants and wild pigs damage the crop (Ramakrishna Ayyar, 262–64; Subramanian, *Curr. Sci.*, 1955, **24**, 209; Doraswami & Iyengar, *Mysore agric. J.*, 1945, **23**, 129; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951, 165).

*Harvesting and Yield*—The crop comes into bearing in 4–5½ months from planting. Harvesting begins a fortnight before the crop is fully mature and continues for a fortnight or so after full maturity; where proper storage facilities for tubers are unavailable, the crop may be left in the field a little longer and tubers dug up as needed. The tubers are considered to be mature and ready for harvest when the leaves begin to turn yellow and drop off. A more reliable indication of maturity of crop is provided by

cutting through a tuber dug out from the field; if the juice dries up readily without discolouration, the tuber has attained maturity; if the cut surface, however, changes to a dark or greenish colour, the tuber is still immature. Vines are cut close to the ground and the field cleared of surface growth. An interval of a week or so between the cutting of vines and harvesting of tubers improves the sweetness of the produce. Harvesting should be done when the soil is dry and the weather is fair. The field is dug up and exposed tubers are lifted to the surface. Care must be taken to prevent injury to tubers by cutting, bruising, etc. which facilitates the entrance of decay organisms. The tubers are dried in the sun for a week, freed from adhering soil and taken to the market (Mollison, III, 196; Mudaliar, loc. cit.; Singh & Bhagchandani, loc. cit.; Boswell, loc. cit.).

The average yield of tubers varies in different areas from 8,000 to 24,000 lb. per acre. There has been considerable improvement in yields since the introduction of selected types. *Pusa Suffaid*, a high yielding variety is reported to give a yield as high as 32,000 lb. per acre (Roberts & Kartar Singh, 380; Milne *et al.*, 116; Mukerji, 270; Ambekar, *Bull. Dep. Agric. Bombay*, No. 146, 1927, 100; Patel, loc. cit.; Mudaliar, loc. cit.; Singh & Bhagchandani, loc. cit.).

*Storage*—Tubers intended for storage are harvested a little later than usual and cured to hasten the healing of wounds caused during lifting. The usual practice in India is to spread the tubers in the sun during the day and either transfer them to a room during the night or cover them with a tarpaulin; exposure to sun is continued for about a week or more. The tubers are then stored in ventilated rooms, frequently inspected and tubers which show signs of rotting are periodically eliminated (*Farm News Release, Indian Coun. agric. Res.*, No. 173, 1956).

Sweet potato tubers may be stored in sand or straw; they may also be stored in pits between layers of wood ash. They may be split longitudinally into slices, sun-dried and stored. In America, the tubers are cured in store houses under controlled temperature and humidity conditions. Curing is effected at 80–95°F., relative humidity 85–90%, the period of treatment varying from one week to three weeks according to the type to be cured. The temperature in the store house is lowered gradually to 50–55°F. (50°F. in some cases), the humidity being maintained at 80–85%. Under these conditions tubers keep well for 3–7 months (Venkataramayya, *Madras agric. J.*, 1947, **34**, 89; Schery, 430; Mudaliar, loc. cit.; Lutz & Simons, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1442, 1948; Thompson, 436–37; Cooley *et al.*, *Econ. Bot.*, 1954, **8**, 21).

### Utilization

Sweet potato is used as food after boiling, baking or frying. It may be candied with syrup or used as puree and in escalloped form. In U.S.A., considerable quantities are canned after peeling. In India, tubers are ground into flour and used for *chapaties* and confectionery. Recipes for preparing various types of dishes from tubers have been worked out. Sweet potato has been used as a raw material for production of starch, pectin, sugar syrup and industrial alcohol (Jacobs, II, 1307; Dawson *et al.*, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 195; *Mem. Dep. Agric. Madras*, No. 36, 1954, 421, 1399).

*Chemical composition*—The average composition of Indian sweet potato is as follows: moisture, 68.5; protein, 1.2; fat, 0.3; carbohydrates, 31.0; and mineral matter, 1.0%. The composition varies with the type of sweet potato, conditions of growth and duration of storage after harvesting. The usual range of values for different constituents is as follows: moisture, 58–75; protein, 0.5–3.5; fat, 0.2–1.5; N-free extr., 18.0–37.0; sugars, 2.2–5.6; fibre, 0.6–2.5; and ash, 0.6–1.5%. Indian types with white flesh contain little or no carotene, while American types with pink flesh (experimentally grown in India) contain as high as 5.4–7.2 mg./100 g. of carotene. Vitamins present in the tubers are: thiamine, 0.09–0.14; riboflavin, 0.05–0.10; and vitamin C, 16–22 mg./100 g. Large tubers generally contain more vitamins than small ones. The concentration of vitamins is higher in the inner core than in the outer portion (*Hlth Bull.*, No. 23, 1951, 36; Thorpe, I, 656; Murthy & Swaminathan, *Curr. Sci.*, 1954, **23**, 14; Sherman, 692; *Chem. Abstr.*, 1951, **45**, 10429).

Sweet potatoes are rich in starch. Sucrose and a few reducing sugars are present, but maltose, mannose, galactose and pentose occur, if at all, only in traces. During storage, a part of the starch is converted into reducing sugars and subsequently into sucrose. Thus in a sample stored for five months, the starch content was reduced from 19.1% to 14.1% while the percentage of reducing sugars (as dextrose) and sucrose increased from 0.9 to 1.7 and 1.9 to 6.1 respectively. Cooking is accompanied by a considerable increase in sweetness as a result of the hydrolysis of starch to maltose and dextrins through the action of β-

amylase. Analysis of cooked tubers gave the following figures: total solids, 32.55; alcohol insol. solids, 18.29; reducing sugars, 6.45; sucrose, 2.23; maltose, 8.64; dextrins, 0.51; and polysaccharides, 14.13% (Jacobs, II, 1303; Thorpe, I, 656).

The nutritive value of sweet potato proteins compares well with other vegetable proteins. Experiments on human subjects receiving steamed sweet potato as food gave the following values for the rates of absorption (av. values) of various constituents: protein, $66.97 \pm 2.38$: fat, $85.66 \pm 8.94$: carbohydrate, $98.50 \pm 0.23$; fibre, $9.66 \pm 5.14$; and ash, $51.81 \pm 6.91$%. The following proteins have been identified: a globulin soluble in 5% sodium chloride, 68.0; water-sol. protein, 11.3; a protein soluble in 0.2% sodium hydroxide, 5.4; prolamin, 4.0; and a protein soluble in hot 5% sodium chloride, 1.3%. The distribution of nitrogen in the purified globulin (N, 15.07%) is as follows: humin N, 2.34; amide N, 8.38; histidine, 1.01; arginine, 4.28; lysine, 3.98; tryptophan, 1.89; tyrosine, 4.44; and threonine, 4.13%. The essential amino acids present in the total proteins are as follows (calculated to 16.0 g. N): arginine, 2.9; histidine, 1.4; lysine, 4.3; tryptophan, 1.8; phenylalanine, 4.3; methionine, 1.7; threonine, 3.8; leucine, 4.8; *iso*-leucine, 3.6; and valine, 5.6 g. (Dawson *et al.*, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 195; *Chem. Abstr.*, 1954, **48,** 9498; 1950, **44,** 3094; Block & Bolling, 492).

The pectic substances (total, 0.78; soluble, 0.43%) present in fresh tubers contain: uronic acid, 60; and methoxyl, 4–5%. Pectin content up to 3% has been reported in certain high-starch types. Other constituents reported in the tubers are: phytin (1.05%), two mono-amino-phosphatides (probably lecithin and cephalin), organic acids (oxalic acid, 0.1%), phytosterolin, phytosterol, resins, tannins and colouring matter (Kertesz, 322, 413; Dawson *et al.*, loc. cit.; Thorpe, I, 656; Winton & Winton, II, 108).

Sweet potato contains the following mineral constituents: calcium, 30; magnesium, 24; potassium, 373; sodium, 13; phosphorus, 49; chlorine, 85; sulphur, 26; and iron, 0.8 mg./100 g.; iodine, 4.5 $\mu$g./kg.; manganese, copper and zinc are present in traces (Sherman, 687; Winton & Winton, II, 110; Patnaik, *Indian J. med. Res.*, 1934, **22,** 259).

The enzymes reported to be present in the tubers are: amylase, protease, invertase, catalase, laccase, arabinase, galactanase, polygalacturonase, peroxidases, monophenolase, catecholase, cytochrome c-oxidase, phosphorylase and phosphatases. The occurrence of two thermolabile trypsin inhibitors and glutathione reductase is also recorded. The amylolytic activity is pronounced (activity of pressed juice of the tuber, 130° Lintner). The amylase present is mainly $\beta$-amylase with optimum activity at *p*H, 5.5–6.0 and temperature, 50–55°; it is most stable in the *p*H range corresponding to its optimum activity. The inner portion of the tubers show greater amylolytic activity than the layers near the surface. The *p*H optimum for phosphatases is 5.3–5.7 (Jacobs, II, 1306; Giri, *J. Indian chem. Soc.*, 1934, **11,** 339; 1938, **15,** 249; Shukla, ibid., 1944, **21,** 223; Sohonie & Bhandarkar, *J. sci. industr. Res.*, 1954, **13B,** 500; Sohonie & Honawar, *Sci. & Cult.*, 1955–56, **21,** 538; Balls *et al.*, *J. biol. Chem.*, 1948, **173,** 9; Arthur & McLemore, *J. agric. Fd Chem.*, 1956, **4,** 553; *Chem. Abstr.*, 1953, **47,** 10070, 10569, 1794; 1952, **46,** 11265).

The tubers infected with black rot (*Ceratostomella fimbriata*) yield an essential oil (0.14%) containing a ketone, ipomoeamarone ($C_{15}H_{22}O_3$; b.p., 140–44°/6 mm.) as the chief constituent. Three substances have been isolated from the acidic fraction of the oil, viz. furan-3-carboxylic acid, *trans*-cinnamic acid and a furan keto acid, named batatic acid ($C_{12}H_{12}O_4$; m.p., 88.5–89.5°). The oil is toxic to animals: oral administration to rats in doses of 0.1–0.2 g. of oil/120–150 g. body wt. proved fatal within 27–42 hr. A dosage of 0.3 g. of oil/day had no ill effects on human subjects. Ipomoeamarone and a fraction of the oil boiling below 120° at 4 mm. possess anthelmintic properties (*Chem. Abstr.*, 1952, **46,** 9263; 1953, **47,** 2361; Kubata & Naya, *Chem. & Ind.*, 1954, 1427).

*Starch*—Sweet potatoes have been utilised commercially for the production of starch in Japan and U.S.A. The process consists of grinding the tubers with lime water and separating the starch from the pulp by washing over a series of fine screens. Lime water (*p*H, 8.8–9.2) flocculates the impurities and dissolves the pigments present. The starch suspension is treated with sodium hypochlorite and centrifuged. It is then dried to *c.* 12% moisture in a vacuum drier, pulverized and screened. The product obtained (recovery, 85%) analyses to: moisture, 13.21; ash, 0.396; protein, 0.069; water soluble matter, 0.11; and starch, 85.57%; amylose content of starch, 17.5–21.7% (av., 20.4%). The granules which are small in size (diam., 3–26 $\mu$; av., 16 $\mu$) resemble corn starch granules in shape rather than tuber starch granules (Radley, II, 14–17; Brautlecht, 146–81; von Loesecke, 327; Gordon *et al.*, *Cereal Chem.*, 1951, **28,** 308).

The starch is suitable for sizing paper and textiles and for use in laundries. It is outstanding for warp sizing purposes; in laundry work it is superior to other starches in imparting smoothness and stiffness to fabrics. It forms a clear stable gel with high holding capacity and forms a useful ingredient of food products, confectionery and bakery industries. It is employed in the manufacture of adhesives and dextrins, compositions for insulating fabrics, and coating formulations for dry cells. It is also used in cosmetics (Radley, II, 16; Thurber *et al.*, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 163).

The spent pulp or pomace left after the extraction of starch is pressed, dried and used as cattle feed. Analysis of pomace gave the following values: dry matter, 90.2; protein, 2.5; fat, 0.3; fibre, 9.6; N-free extr., 71.8; mineral matter, 6.0; digestible protein, 0.4; and total digestible nutrients, 69.0%; and nutritive ratio, 171.5 (Thurber *et al.*, loc. cit.; Morrison, 1064).

*Flour* Sweet potato flour, prepared by dehydrating and grinding the tubers, is used as a supplement to cereal flours in the preparation of bakery products, puddings and milk jelly (*firni*). It can be mixed with wheat flour up to 25% for making *chapaties* and bread. It acts as a dough conditioner in bread manufacture; it also functions as a stabilizing agent in ice-cream. It may be used in brewing along with malt flour, as it contains both starch and amylase. A mixture of sweet potato flour and groundnut cake flour, in 4 to 1 proportion, is superior to rice in nutritive value [Jain *et al.*, *J. sci. industr. Res.*, 1951, **10A**, 332; Murthy *et al.*, ibid., 1950, **9B**, 173; Dawson, *Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 204; *Mem. Dep. Agric. Madras*, No. 36, 1954, 879; Cobb, *Chemurg. Dig.*, 1949, **8**(5), 19].

Sweet potato flour can be employed as a coagulant in slurry thickeners in the process of extracting alumina from bauxite. It is also used as moulding sand conditioner (Cobb, loc. cit.).

*Feed* Low grade sweet potato is utilised in U.S.A. as a carbohydrate-rich feed for livestock, especially pigs, after chopping and dehydration. The dried material is equal to corn in total digestible nutrients, but low in protein. It is usually supplemented with protein-rich feeds. The average composition of dried sweet potato meal is as follows: dry matter, 90.2; protein, 4.9; fat, 0.9; fibre, 3.3; N-free extr., 77.0; mineral matter, 4.1; calcium, 0.15; and phosphorus, 0.14%; *digestibility coefficients:* protein, 14; fat, 74; fibre, 37; and N-free extr., 90%; total digestible nutrients, 72.7%; and nutritive ratio, 102.9. Feeding trials on pigs have shown that cooked meal with protein supplement produced as much gain in weight as did corn with the same supplement. Chopped tubers are also suitable for ensilage [Morrison, 391, 556, 1064; Cobb, *Chemurg. Dig.*, 1949, **8**(5), 19].

The vines serve as a nutritive and palatable green feed for cattle. The average yield of vine in Madras is reported to vary from 8,000 to 29,000 lb. per acre. When grown for fodder in November–December, a yield of 55,000–70,000 lb. per acre in 3–4 cuttings is reported. The feeding value of vines is approximately equal to that of alfalfa hay; they are stated to increase the milk yield. The vines may also be ensiled to give a silage comparable to corn silage in nutritive value. Analysis of the dried vines gave the following values: dry matter, 90.7; protein, 12.6; fat, 3.3; fibre, 19.1; N-free extr., 45.5; mineral matter, 10.2; digestible protein, 8.9; and total digestible nutrients, 51.7%; and nutritive ratio, 4.8 (Mudaliar, *Madras agric. J.*, 1950, **37**, 421; *Mem. Dep. Agric. Madras*, No. 36, 1954, 596; Morrison, 392, 1016; Sen, *Indian Fmg*, 1949, **10**, 288).

*Other products*—Edible and fermentable syrups have been prepared from sweet potatoes. The tubers are cooked with water, pulped and saccharified by treatment with malt (0.2%) at 60°. The solution is clarified and concentrated to *c.* 70% solid content. The product is less sweet than canesugar syrup; it contains: water, 30.1; ash, 1.75; protein, 2.45; maltose, 43.0; sucrose, 7.0; and dextrins, 14.0%. A glucose syrup is prepared from sweet potato starch by a process similar to that employed for producing syrup from corn starch (Dawson, *Yearb. Agric. U. S. Dep. Agric.*, 1950–51, 204; Brautlecht, 179; Sen, *Indian Fmg*, 1949, **10**, 288).

Sweet potato forms a valuable raw material for the fermentative production of industrial alcohol, lactic acid, acetone, butanol, vinegar and yeast. Raw tubers and pressed juice are employed for the preparation of alcoholic beverages after saccharification with liquid *koji*. Carotene concentrates have been prepared from selected types rich in carotene and a process for the extraction of anthocyanin dyes from the peelings has been patented (Thurber *et al.*, *Yearb. Agric. U. S. Dep. Agric.*, 1950–51, 163; *Chem. Abstr.*, 1951, **45**, 4874, 5416; 1950, **44**, 6571; 1952, **46**, 11493; 1955, **49**, 15165).

Sweet potato pectin is comparable to apple pectin in jellying properties. It is obtained as a by-

product from peel and trim wastes of sweet potato canneries. The starch present is solubilised by treatment with amylase and the residue employed for pectin extraction. The pectin may also be recovered from the pulp residue after starch recovery (Dawson *et al., Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 195).

Tender tops and leaves of the vine are used as vegetable in the Philippines; they may be used in soups and also as a salad after steaming. Analyses of edible portions of two samples of vine gave the following values: moisture, 87.1, 82.8; nitrogen, 0.566, 0.592; ether extr., 0.67, 0.81; crude fibre, 1.4, 1.5; and ash, 1.59, 1.35%; calcium, 81.2, 64.0; phosphorus, 67.3, 66.3; iron, 10.37, 5.82; carotene, 3.61, --; thiamine, 0.065, 0.169; riboflavin, 0.173, 0.297; niacin, 0.94, 0.89; and ascorbic acid, 25.0, 28.8 mg./100 g. Vitamin E (tocopherol) content of the leaves is 8.1 mg./100 g. (Intengan *et al., Philipp. J. Sci.*, 1954, **83**, 193, 208; *Chem. Abstr.*, 1947, **41**, 5643).

Fresh vines and tubers when cut exude a latex which on exposure to air, becomes sticky and ultimately sets to a hard resinous material. The resinous principle, jalapin (scammonin), has been identified; it is the active ingredient of a boiler compound used in Japan. The latex contains only traces of caoutchouc (Dawson *et al., Yearb. Agric. U. S. Dep. Agric.*, 1950–51, 195).

Vines and tubers contain fungicidal and bactericidal substances, among them a buff-coloured crystalline solid, active against the Gram-negative *Escherichia coli* and a clear brown liquid, effective against Gram-positive bacteria (especially *Mycobacteria*), and fungi (Schaffer *et al., Yearb. Agric. U.S. Dep. Agric.*, 1950–51, 727).

The root is considered laxative. In Malaya, a drink prepared from the root is given to allay thirst in fever. Tops and tender shoots are used in poultices and leaves as a maturative cataplasm. In Ghana (Gold Coast), the leaves are ground with salt and applied to whitlow. A paste of roots or leaves is used as an application to scorpion bites (Kirt. & Basu, III, 1719; Burkill, II, 1248; Quisumbing, 759; Nadkarni, I, 685).

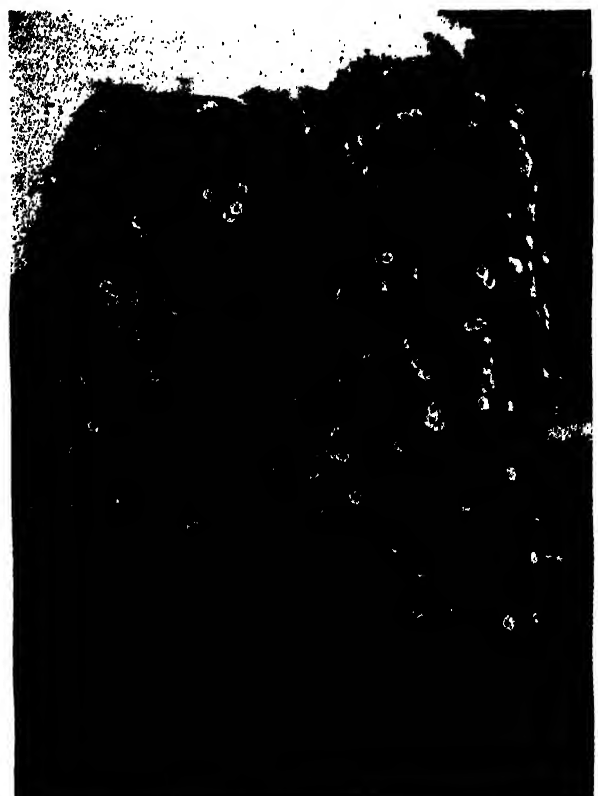
**I. cairica** (Linn.) Sweet syn. *I. palmata* Forsk.
RAILWAY CREEPER

Fl. Br. Ind., IV, 214; Fl. Malesiana, Ser. I, **4**(4), 478.

An extensive perennial climber with tuberous root, found almost throughout India. Leaves deeply palmately 5–7 lobed; flowers campanulate, violet-purple with purple tube, solitary or triple, in axillary pedunculate cymes; capsules small, ovoid, glabrous; seeds 4, pubescent with woolly margins. *I. cairica* is a decorative plant commonly grown in gardens, trellises and railway platforms as screens. It flowers almost all the year round and is propagated by seeds or cuttings (Bor & Raizada, 6).

The tuberous roots and stems, though bitter, are used as food in Hawaii. Roots and leaves are slightly cyanogenetic. The vine is used as cordage for tying. In S. Africa, crushed leaves are used in applications for body rashes (Neal, 624; Watt & Breyer-Brandwijk, 152; Quisumbing, 1045).

The seeds of *I. cairica* are considered purgative and used as a substitute for the seeds of *I. nil* (q.v.). A pale yellow glucosidic compound (m.p., 118–19°), resembling muricatin A from *Calonyction muricatum* and possessing marked purgative activity, has been isolated from the seeds; on alkaline hydrolysis, it yields a colourless product (m.p., 104–106°) with no pharmacological action. The seeds contain a pale yellow fatty oil (11.5%) with the following characteristics: sp. gr.$^{33°}$, 0.9280; $n_D^{32}$, 1.4730; acid val., 2.1;



*F.R.I., Dehra Dun, Photo: M. N. Bakshi*

FIG. 133. IPOMOEA CAIRICA—IN FLOWER

sap. val., 186.0; iod. val. (Wij's), 117.3; acetyl val., 32.7; R.M. val., 2.2; Polenske val., 0.3; Hehner val., 88.7; and unsapon. matter, 2.8%. The component fatty acids of the oil are: palmitic, 8.29; stearic, 11.43; arachidic, 2.95; behenic, 0.81; oleic, 24.5; linoleic, 32.66; and linolenic, 4.8%. The unsaponifiable matter contains β-sitosterol (Handa *et al.*, *J. sci. industr. Res.*, 1956, **15B**, 727; Chaudhary *et al.*, *Curr. Sci.*, 1957, **26**, 148).

**I. carnea** Jacq.

Bor & Raizada, 6, Fig. 5.

A large diffuse or straggling shrub with milky juice, native of S. America and introduced into India as an ornamental plant. Leaves ovate-cordate, entire, acuminate; flowers large, campanulate, pale rose, mauvish pink or light violet, in lax, dichotomous, axillary and terminal peduncled cymes; capsules, 0.5 in. long, glabrous; seeds silky.

*I. carnea* is cultivated in gardens in many parts of India; it is sometimes grown as a hedge. The plant is propagated by cuttings. It produces dense foliage and flowers practically throughout the year except during the cold months. It is drought-resistant and can be raised both under rain-fed and irrigated conditions. It is used as a green manure crop in Madras. It stands pruning well. Under rain-fed conditions, a border crop, one mile in length, gave, in six cuttings, 75,000 lb. of green matter in one year; under irrigated conditions, the yield was nearly double [Ponnaiya *et al.*, *Indian Fmg, N. S.*, 1954 55, **4**(12), 14; Varadachari, *World Crops*, 1957, **9**, 35; *Madras agric. J.*, 1953, **40**, 509].

The plant is toxic to live-stock. The leaves contain a polysaccharide ipomose, an anthracene glucoside, a gum, jalapin, and saponins. The presence of two toxic principles, one soluble in water and the other in ether is reported. When administered intravenously, the water soluble toxin caused haemolysis and reduced the blood pressure; the ether soluble toxin affected the central nervous system, including the respiratory and cardiac regulatory centres. When given orally the ether-soluble toxin acted as a mild purgative [Katyal, *Indian Fmg, N.S.*, 1955-56, **5**(12), 39; *Chem. Abstr.*, 1948, **42**, 7837].

**I. digitata** Linn.

D.E.P., IV, 484; C.P., 686, 1120; Fl. Br. Ind., IV, 202; Fl. Malesiana, Ser. I, **4**(4), 483; Kirt. & Basu, Pl. 662.

Sans.—*Bhumikushmanda, vidari*; Hindi—*Bilaikand*; Beng.—*Bhumikumra*; Mar.—*Bhuikobola, vidarikand*; Tel.—*Bhuchakragadda*; Tam.—*Palmudangi*; Mal.—*Mutalakkanta, palmutakku*; Kan.—*Bhumichekrigadde, buja-gumbala*; Oriya—*Bhuinkokaru*.

An extensive perennial climber with tuberous roots, found in Bihar, Orissa, West Bengal, Assam, Deccan and west coast from Konkan to Kerala, mostly in moist areas, monsoon forests and coastal tracts. Leaves large, palmately 5–7 lobed; flowers widely campanulate, pink or red purple, few to many in axillary corymbose cymes; capsules small, ovoid; seeds 4, black, woolly.

The plant is grown for ornamental purposes and trained against trellises and pillars. It is propagated by cuttings (Gopalaswamiengar, 357)

The tuberous root of the vine is of large size with yellowish brown coat. It is brittle, mucilaginous and bitter in taste. It contains a resin, similar to jalap resin, and is considered tonic, alterative, aphrodisiac, demulcent, lactagogue and cholagogue. It is recommended for emaciation in children. It enters into the composition of a compound decoction which is nutritive, diuretic and expectorant, and useful in fevers and bronchitis. Powdered root is given for diseases of the spleen and liver, for menorrhagia, debility and fat accumulation. A decoction is prescribed for consumption. In Malaya, the crushed root is applied to swellings [Dymock, Warden & Hooper, II, 536; Koman, 1920, 32; Rama Rao, 277; Fl. Malesiana, Ser. I, **4**(4), 483].

The stems and leaves of the plant are used as cattle fodder. Fresh leaves contain 6.3 mg./100 g. of carotene. In Bombay, the seeds are used for coagulating milk [Acharya & Malpoorwala, *J. Univ. Bombay*, *N.S.*, 1952, **21A** (3), 47].

**I. eriocarpa** R. Br. syn. *I. hispida* Roem. & Schult.

D.E.P., IV, 485; Fl. Br. Ind., IV, 204; Fl. Malesiana, Ser. I, **4**(4), 462.

Tel.—*Purititige*; Mal.—*Pulichevidu*; Oriya—*Paninoi*.

Punjab—*Bhanwar*; Delhi—*Ghiabato, boota*; Assam—*Kalman*.

A herbaceous slender, twining, villous annual, found almost throughout India ascending up to 4,000 ft. in the Himalayas; it is common in open grasslands, hedges, fields, secondary forests and dry areas. Leaves oblong-cordate, acute, hairy; flowers small, campanulate, pink or purple, axillary, solitary or in multiflowered cymes; capsules small, globose, hairy; seeds 4, glabrous.

FIG. 134. IPOMOEA ERIOCARPA—FLOWERING BRANCH

*I. eriocarpa* has been tried as a green fodder in S. India. It is useful for milch cattle. It is hardy and drought-resistant and thrives on sandy loams and red and black soils. As a fodder crop, it is sown pure or mixed with horsegram, wheat and jowar. In experimental trials at Coimbatore, a yield of 28,000 lb. of fodder per acre has been recorded. The fodder is considered to be equal to sunn hemp in nutritive value. Analysis of the sun-dried plant cut at the flowering stage gave the following values: moisture, 16.13; crude protein, 15.56; ether extr., 2.40; carbohydrates, 35.12; crude fibre, 20.78; total ash, 10.01; soluble mineral matter, 8.88; phosphorus ($P_2O_5$), 0.55; calcium (CaO), 1.62; and potassium ($K_2O$), 3.05%; starch equivalent, 71.5 lb./100 lb. and nutritive ratio, 1:2.56. The plant is a soil binder and is effective in smothering weeds (*Mem. Dep. Agric. Madras*, No. 36, 1954, 596; Ayyangar & Rajagopal, *Madras agric. J.*, 1939, **27**, 147).

The leaves and stems are eaten as vegetable. The seeds are rich in proteins; they are edible and nutritious. They contain: moisture, 9.22; crude protein, 22.25; ether extr., 9.52; carbohydrates, 44.44; crude fibre, 10.63; soluble mineral matter, 3.83; and silica, 0.11%. The seeds are reported to contain a resin similar to that present in the seeds of *I. nil* (Ayyangar & Rajagopal, loc. cit.; Wehmer, II, 1012).

The plant is boiled in oil and used as an application for headache, rheumatism, leprosy, epilepsy, ulcers and fevers. It is also applied to neck sores of bulls (Kirt. & Basu, III, 1729; Rama Rao, 278; Bressers, 99; Fl. Delhi, 244).

**I. maxima** (Linn. f.) G. Don syn. *I. sepiaria* Koenig ex Roxb.

D.E.P., IV, 491; Fl. Br. Ind., IV, 209; Fl. Malesiana, Ser. I, **4**(4), 472.

Hindi & Beng.—*Bankalmi*; Mar. *Amtivel*; Guj.—*Hanumanvel*; Tel.—*Mettatuti, puritilige*; Tam.—*Manjigai, talikkirai*; Mal.—*Tirutali*; Oriya—*Bilona, mushakani*.

A herbaceous slender, perennial twiner found almost throughout India in hedges, near streams and tanks. Leaves ovate-cordate, entire, acute; flowers large, funnel-shaped, pale purple, pink or white with a purple eye, in many-flowered, pedunculate, umbellate or subumbellate, axillary cymes.

The plant is eaten as pot-herb and used as fodder for cattle. The juice of the plant is considered deobstruent and diuretic. It is used as an antidote to arsenic (Kirt. & Basu, III, 1723).

***I. nil** (Linn.) Roth syn. *I. hederacea* auct., non Jacq.

D.E.P., IV, 485; C.P., 686; Fl. Br. Ind., IV, 199; Fl. Malesiana, Ser. I, **4**(4), 465.

Sans.—*Krishnabija, shyamabija*; Hindi *Kaladana, mirchai*; Beng. *Kaladanah, nilkalmi*; Mar.—*Nilpushpi, nilvel*; Guj.—*Kaladana, kalkumpan*; Tel.—*Jirika, kolli*; Tam. *Kakkattan, sirikki*; Kan.—*Ganribija*; Oriya *Khanikhondo*.

Deccan *Kalizirki, zirki*; Kashmir—*Hub-ul-nil*; Punjab—*Bildi, ishpecha, ker, kirpawa, phaprusag*.

An extensive, hairy, herbaceous annual or perennial twiner, found throughout India up to a height of 6,000 ft. in the Himalayas; it is frequently grown in gardens for its ornamental flowers, and often runs wild in hedges and waste places. Leaves alternate, ovate-cordate, 3-lobed; flowers large, funnel-shaped,

* This species has been erroneously identified by a number of authors with the North American species *I. hederacea* (Linn.) Jacq. The true *I. hederacea* of North America is sometimes grown in Indian gardens and has not been found wild (Fl. Malesiana, Ser. I, **4**(4), 465; Santapau, *J. Bombay nat. Hist. Soc.*, 1947 48, **47**, 346).

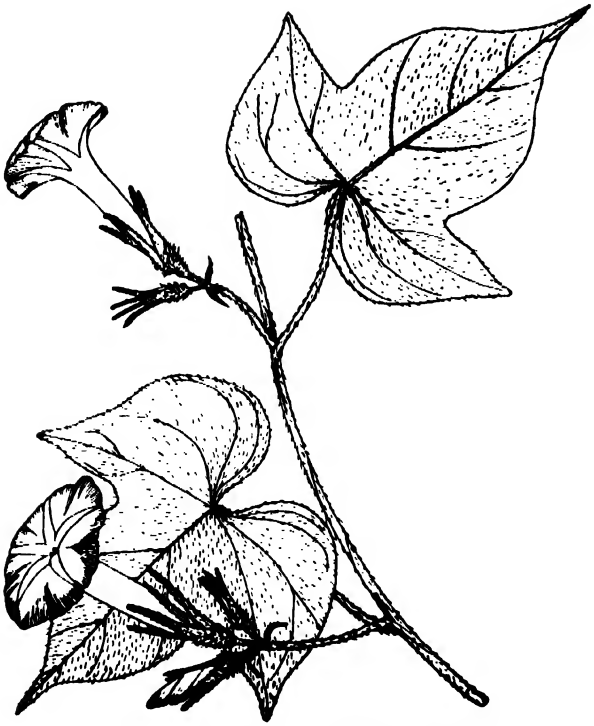


FIG. 135. IPOMOEA NIL—FLOWERING BRANCH

pale or bright blue tinged with pink, turning red or reddish on ageing, in 1–5 flowered umbellate cymes; capsules ovoid, sub-globose, smooth; seeds 4 or 6, black, grey puberulent.

The dried seeds of *I. nil* are sold in bazaars under the name of KALADANA and used as purgative. The seeds are black in colour except for a brownish spot at the hilum, small in size (¼–⅓ inch in length), angular and of the shape of the segment of a sphere; 100 seeds weigh 3–4 g. Taste at first sweetish, later acrid and disagreeable. Kaladana is an active cathartic and is official in the Indian Pharmacopoeia. It is used as a substitute for jalap (*Exogonium purga* Benth.). The purgative action is due to a resin which is extracted from the seeds along with inert resinous matter by alcohol. Both seeds and the total resin extract are employed as cathartic in doses of 30–45 gr. and 4–8 gr. respectively. In overdoses they produce symptoms of irritant poisoning. Other preparations of kaladana used in medicine include an extract, a tincture (1 in 5), and a compound powder (Pulvis Kaladanae Compositus) consisting of seeds, potassium hydrogen tartrate and powdered ginger (Bentley & Trimen, III, 185; I.P., 354, 509; B.P.C., 1949, 459; Modi, 559; Dymock, Warden & Hooper, II, 531; Allport, 125).

Among the adulterants and substitutes of kaladana are the seeds of some *Ipomoea* spp., *Crotalaria juncea* Linn., *Acacia arabica* Willd., *Peganum harmala* Linn. and *Ocimum basilicum* Linn. (B.P.C., 1949, 460).

Commercial samples of kaladana contain 14–15% of crude resinous matter with nauseating acrid taste and disagreeable odour; the resin can be fractionated into a glycosidal part and a non-glycosidal part. The activity of the drug was formerly attributed to the glycosidal fraction, named pharbitsin, consisting of an ether-soluble portion (tiglic acid, methyl-ethyl acetic acid, and $\alpha$-methyl-$\beta$-oxybutyric acid) and an ether-insoluble portion (pharbitinic acid, giving on hydrolysis glucose, rhamnose and ipurolic acid). More recent work has shown that the glycosidal resin is inert; the activity of the drug resides in the non-glycosidal resin (2% of the drug) and causes copious purgation in doses of 250 mg. (Sen Gupta & Gupta, *Indian J. Pharm.*, 1948, **10**, 106; Wehmer, II, 1012; U.S.D., 1955, 1728; B.P.C., 1949, 460; *Chem. Abstr.*, 1924, **18**, 1879).

Besides the resinous matter, the seeds contain a fixed oil (12.4%), and small amounts of saponin, mucilage and tannin. Extracted oil is pale yellow in colour, with an unpleasant odour and has the following characteristics: sp. gr.$^{20°}$, 0.918; $n^{20°}$, 1.474; $\eta^{20°}$, 0.2938; sap. val., 190.48; acetyl val., 5.19; acid val., 3.45; iod. val., 121.5; and unsapon. matter, 1.98%. The mixed fatty acids contain: palmitic, 5.93; stearic, 20.37; arachidic, 7.79; behenic, 1.29; linolenic, 5.99; linoleic, 14.54; and oleic, 43.98%. The unsaponifiable matter contains coprosterol (I.P.C., 129; Kathpalia & Dutt, *Indian Soap J.*, 1947–48, **13**, 77; *Chem. Abstr.*, 1927, **21**, 2391).

The flowers contain anthocyanin pigments. The colouring matter of red flowers is pelargonin chloride ($C_{27}H_{31}O_{15}Cl$, 3,5-diglucoside of pelargonidin chloride): deep violet and red violet flowers contain peonin chloride ($C_{28}H_{33}O_{16}Cl$) which is a 3,5-diglucoside of peonidin chloride, $C_{16}H_{13}O_6Cl$. Fresh capsules of *I. nil* are eaten as vegetable [Mayer & Cook, 224, 229; Thakkar & Singh, *Indian Fmg, N.S.*, 1953–54, **3**(10), 12].

*I. nil* sometimes occurs as a weed in sugarcane and wheat fields. It is a menace to sugarcane cultivation in Bihar, causing a loss of 20–25% of the crop. It can be checked by weeding the field in the early stages and other cultural practices. Spraying with Agroxone (1%), Fernoxone (0.1–0.2%) and

Phenoxylene 30 (0.3–0.6%) at the rate of 100 gal./acre is reported to be effective [Thakkar & Singh, *Indian Fmg, N.S.*, 1953–54, **3**(10), 12 ; Kaul, *Allahabad Fmr*, 1951, **25**, 103].

**I. obscura** (Linn.) Ker-Gawl.

D.E.P., IV, 488 ; Fl. Br. Ind., IV, 207 ; Fl. Malesiana, Ser. I, **4**(4), 471 ; Kirt. & Basu, Pl. 659A.

MAR.—*Pilibonvari* ; GUJ.—*Gumbadvel* ; TEL.—*Nallakokkita* ; TAM.—*Chirudali, siruttali* ; MAL.—*Cheruttali*.

A slender, twining annual, found almost throughout India up to an altitude of 3,000 ft., in grasslands, hedges and waste lands. Leaves entire, ovate-cordate, acute ; flowers small, funnel-shaped, yellow or white with a purple spot, in axillary cymes ; capsules ovoid, straw-coloured, glabrous ; seeds 2–4, dark-brown, densely velvety.

The leaves of *I. obscura* are mucilaginous with a pleasant smell. They are used as an application to aphthous affections after toasting, powdering and boiling in ghee. In admixture with the leaves of *Argyreia mollis*, they are used for sores [Kirt. & Basu, III, 1723 ; Fl. Malesiana, Ser. I, **4**(4), 472].

**I. pes-caprae** (Linn.) Sweet syn. *I. biloba* Forsk. ; *I. maritima* R. Br.

D.E.P., IV, 482 ; Fl. Br. Ind., IV, 212 ; Fl. Malesiana, Ser. I, **4**(4), 475 ; Kirt. & Basu, Pl. 667A.

HINDI—*Dopatilata* ; BENG.—*Chhagalkuri* ; MAR.—*Maryadvel, samudraphen* ; GUJ.—*Marjadavela* ; TEL.—*Balabanditige, bedatige, chivulapillitige* ; TAM.—*Adambu, attukkal, musattalai* ; KAN.—*Adumbaballi, bangadaballi* ; MAL.—*Adumbu-valli, atampa, chuvannatampu* ; ORIYA—*Kanchonaluota, kasari-nai*.

An extensively climbing or trailing, perennial herb with thick long root, found in Sundarbans, eastern and western coasts, Pilani (Rajasthan) and Andaman Islands, usually on sandy shores and occasionally inland along river banks, ditches, canals and way sides. Leaves orbicular, deeply bilobed, fleshy ; flowers large, funnel-shaped, brilliant rose-purple, pink or violet in axillary pedunculate cymes ; capsules small, ovoid, glabrous ; seeds 4, dark brown, villously tomentose.

The plant is useful as a sand binder. It is eaten by most animals ; cows fed on it yield tainted milk. The leaves are used as vegetable in Zanzibar and Pemba (Williams, 310).

The plant is mucilaginous and is considered astringent, stomachic, alterative, tonic, diuretic and laxative. It is said to be useful for skin affections. In Cambodia, it is used in the treatment of blennorrhagia and piles. Leaves are used as an external application for rheumatism, dropsy and colic, and the juice of the leaves is taken as a diuretic. In eastern Malayasia, leaf poultices are applied to boils, swellings, wounds, ulcers and carbuncle. In Madagascar, leaves are recommended for inflammation of the *prolapsus ani* and whitlow. The seeds are used as a remedy for stomach ache and cramp. In Malaya and Indonesia, the stem juice is applied to bites and stings of fishes. The dried juice of the root is used as a purgative. The roots are reported to contain a saponin [Chopra, 499 ; Kirt. & Basu, III, 1726 ; Nadkarni, I, 689 ; Rama Rao, 280 ; Fl. Malesiana, Ser. I, **4**(4), 476 ; Burkill, II, 1249–50 ; Dymock, Warden & Hooper, II, 537 ; Wehmer, II, 1013].

The plant contains a mucilage, a volatile oil (0.05%), resins (7.3%), bitter substances, red colouring matter, pentatriacontane, triacontane, a sterol ($C_{29}H_{50}O$), and behenic, melissic, butyric and myristic acids. The volatile oil has the following constants: sp. gr.$^{28}_{28}$, 0.9626 ; and $n^{26}$, 1.4703 (*Chem. Abstr.*, 1938, **32**, 5031, 7673).

**I. pes-tigridis** Linn.

D.E.P., IV, 488 ; Fl. Br. Ind., IV, 204 ; Fl. Malesiana, Ser. I, **4**(4), 467.

BENG.—*Langulilata* ; TEL.—*Chikunuvvu, mekamadugu, puritikada* ; TAM.—*Pulichovadi, punaikkirai* ; MAL.—*Pulichuvatu* ; ORIYA—*Bilaipado*.

DELHI—*Ghiabati* ; MADHYA PRADESH—*Panch-patri*.

A spreading or twining herbaceous annual, found almost throughout India ascending up to 4,000 ft., usually in hedges, grasslands, waste places, bushes, fields and sea coast. Leaves deeply palmately 5–9-lobed, hairy ; flowers funnel-shapel, white or pink, in axillary cymes ; capsules ovoid, papery, glabrous ; seeds 4, minutely velvety.

FIG. 136. IPOMOEA PES-TIGRIDIS—FLOWERING BRANCH

The plant may be used as a feed for live-stock both in the green state and as hay. In North India, it grows profusely during the monsoon and remains green and succulent for 3–4 months: two cuttings may be obtained but the second cut gives low yield. The plant can be cultivated along with jowar for forage purposes. In nutritive value, the plant compares favourably with legumes, being rich in protein, calcium and phosphorus. Analysis of the green feed (sample contained both immature and mature seeds) and hay gave the following values (dry basis): *green feed:* crude protein, 12.27; fat (ether extr.), 3.00; N-free extr., 48.21; fibre, 26.23; ash, 10.29; calcium, 0.917; and phosphorus, 0.479%; *digestibility co-efficients* (for sheep): dry matter, 66.8; crude protein, 72.4; ether extr., 58.5; fibre, 51.7; and N-free extr., 78.3%; *hay*: crude protein, 13.58; ether extr., 3.50, N-free extr., 44.02; crude fibre, 27.02; ash, 11.88; calcium, 1.480; and phosphorus, 0.344%; *digestibility co-efficients:* dry matter, 51; crude protein, 57.1; ether extr., 67.9; N-free extr., 57.0; and crude fibre, 41.7%. The digestible nutrients present in green feed (84% moisture) and hay (10% moisture) were respectively as follows: digestible crude protein, 1.43, 7.0; total digestible nutrients, 10.3, 45.0; and starch equivalent, 8.9, 30.0 lb./100 lb. Feeding trials on farm animals showed positive balances for nitrogen, calcium and phosphorus (Talapatra & Barsaul, *Indian J. vet. Sci.*, 1957, **27**, 45).

The mature seeds are black and resemble sunn hemp seeds. They contain: crude protein, 30.19; fat (ether extr.), 11.10; calcium, 0.38; and phosphorus, 1.03% (Talapatra & Barsaul, loc. cit.).

The herb is used in the treatment of boils and carbuncles, and as an antidote to dog bites. In Philippines and Indonesia, leaves are applied as poultices to boils, pimples and sores. The root is used as a purgative. It is reported to contain a resin (Kirt. & Basu, III, 1721; Quisumbing, 763; Chopra *et al.*, 142).

**I. purpurea** (Linn.) Roth MORNING GLORY

Fl. Br. Ind., IV, 200; Bor & Raizada, 9, Fig. 9; Fl. Malesiana, Ser. I, **4**(4), 465.

A herbaceous, hairy, twining annual, native of tropical America, found throughout the greater part of India ascending up to 7,000 ft. in the Himalayas; it is occasionally grown in gardens for its beautiful flowers. Leaves broadly ovate-cordate, entire or 3-lobed; flowers large, funnel-shaped, varying in colour from white to dark purple, in axillary pedunculate cymes; capsules globular, glabrous; seeds 6 or less, glabrous or sparsely pilose at the hilum.

*I. purpurea* occurs in many forms under cultivation, some of them with double flowers. It is easily raised from seeds: it grows rapidly producing dense foliage. It is suitable for covering arbors, verandahs and walls (Bor & Raizada, 9–10; Bailey, 1947, II, 1657).

The plant is used by the Zulus of southern Africa as a purgative and anti-syphilitic. The stem contains a soft resin (4.8%), essential oil (0.018%), tannin and colouring matter. The resin is the active principle; it contains ipuranol which is identical with sitosterol glucoside ($C_{35}H_{60}O_6$; m.p., 300–305°), ipurolic acid ($C_{19}H_{28}O_4$), *d*-methyl acetic acid, hydroxylauric acid (m.p., 69–70°) and glucose. On hydrolysis, the resin yields pentatriacontane, formic, butyric and higher volatile acids, stearic acid, palmitic acid, azelaic acid (?), and a substance which gives catechol reaction (Watt & Breyer-Brandwijk, 152; Wehmer, II, 1011; Thorpe, VI, 96; Tschirch & Stock, II, 1628).

**I. quamoclit** Linn. syn. *Quamoclit pinnata* Bojer; *Q. vulgaris* Choisy CYPRESS VINE, INDIAN PINK

D.E.P., IV, 491; Fl. Br. Ind., IV, 199; Fl. Malesiana, Ser. I, **4**(4), 482.

HINDI—*Kamalata*; BENG.—*Tarulata, kamalata*; MAR.—*Vishnukrantu, sitachekesa*; TEL.—*Kasiratnamu*; TAM.—*Kembumalligai, mayirmanikkam*; KAN.—*Kamalate, kempumallige*; MAL.—*Suriyakanthi*; ORIYA—*Kunjolota.*

A graceful slender, glabrous, twining annual, native of tropical America, grown throughout India in gardens as an ornamental plant and occasionally found as an escape. Leaves pinnately lobed into numerous filiform segments; flowers salver-shaped, brilliant crimson, scarlet or white, in axillary pedunculate cymes; capsules ovoid, smooth; seeds 4, conical, glabrous, tubercled.

*I. quamoclit* is propagated from seeds in early spring. It grows rapidly and yields an abundance of handsome flowers. The leaves are used as pot-herb. The plant is considered cooling. It is used in Queensland as a purgative, for snake-bite and as snuff. Pounded leaves are applied as poultice to bleeding piles and, at the same time, the juice, mixed with hot ghee is given internally. The leaves are used as a plaster for carbuncles. In Spain, the powdered root is given as a sternutatory. The leaves and stems are reported to contain small amounts of alkaloids. The leaves are cyanogenetic; traces of hydrocyanic acid

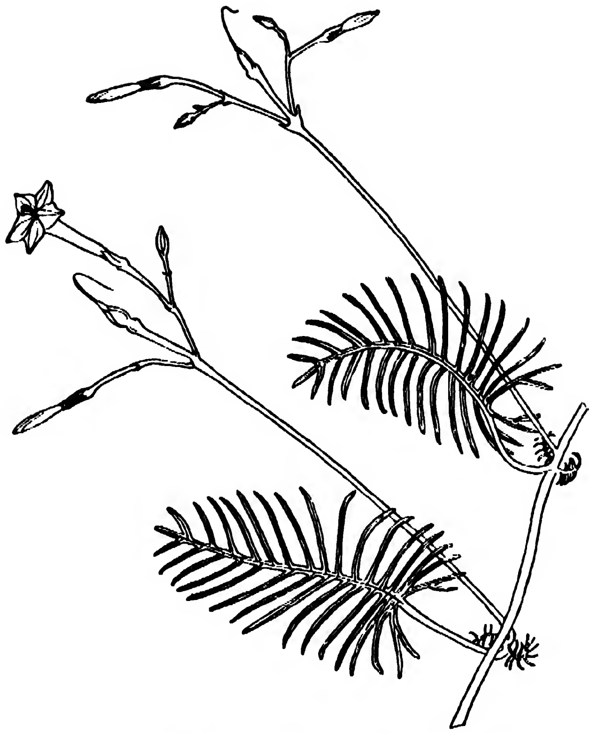


FIG. 137. IPOMOEA QUAMOCLIT—FLOWERING BRANCH

are present also in roots, stems and flowers (Bor & Raizada, 3; Bressers, 100; Kirt. & Basu, III, 1712; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 42; *Chem. Abstr.*, 1950, **44**, 2180; Quisumbing, 1045).

**I. uniflora** Roem. & Schult.=*Aniseia martinicensis* (Jacq.) Choisy syn. *A. uniflora* Choisy

Fl. Br. Ind., IV, 201; Fl. Malesiana, Ser. I, **4**(4), 435.

A slender, prostrate or twining herb found in Bundelkhand (U.P.), Bihar, Lakhimpur (Assam), east coast and west coast from Konkan to Kerala. Leaves lanceolate-oblong, entire; flowers solitary, campanulate, white; capsules ovoid, glabrous; seeds ovoid, dark brown or black, glabrous, margin minutely trigose. The plant is usually found in marshy thickets, hedges, river banks, margins of tanks and backwaters.

The plant is used as vegetable in Malaya and Indonesia (Borneo). It is purgative and its juice is given in bilious dyspepsia. The seeds are said to be used by the Mundas as purgative [Fl. Malesiana, Ser. I, **4**(4), 436; Kirt. & Basu, III, 1717; Bressers, 99].

A number of species of *Ipomoea*, other than those mentioned, are of minor importance either as ornamental plants or medicinal plants. *I. angulata* Lam. syn. *I. coccinea* C.B. Clarke (Fl. Br. Ind.), non Linn.; *I. phoenicea* Roxb.; *Quamoclit phoenicea* Choisy, is a pretty annual twiner with ovate-cordate leaves and salver-shaped, crimson flowers, cultivated in gardens almost throughout India. Its root is considered sternutatory and is used by the Mundas for snake bite (Kirt. & Basu, III, 1713; Bressers, 100).

*I. coptica* (Linn.) Roth syn. *I. dissecta* Willd. is a herbaceous, glabrous, prostrate or twining annual, with digitate, 3–7-lobed leaves and small, funnel-shaped, white flowers, found in the upper Gangetic plain, Gujarat and east coast. The herb is used in Ghana (Gold Coast) for chest complaints in children; in North Nigeria, a cold infusion of the plant is given for giddiness or intoxication. Leaves are reported to contain chlorogenic acid (Dalziel, 438; Wehmer, II, 1014).

*I. dasysperma* Jacq. f.—*I. tuberculata* Ker-Gawl. (Guj.—*Dipdavel*) is a pretty twiner with pedately 5–7-lobed leaves and salver-shaped, yellow, pale rose, or buff coloured flowers purple in the centre, found in the upper Gangetic plain, Bombay, Madras and Kerala. The seeds of the plant are used as an antidote for hydrophobia (Kirt. & Basu, III, 1728).

*I. dichroa* Choisy syn. *I. pilosa* Sweet is a twining annual, with broadly ovate-cordate, entire or 3-lobed leaves and small, funnel-shaped, white, pink or purple flowers, found almost throughout India ascending up to 3,000 ft. The seeds of the plant are reported to contain a fatty oil and a resin probably similar to that present in the seeds of *I. nil.* Dried leaves are used as an application for burns in West Africa. The seeds are used as a purgative in mixture with the seeds of *Hibiscus sabdariffa* (Dalziel, 439; Wehmer, II, 1012).

*I. ficifolia* Lindl., a native of Argentina, has been introduced into Indian gardens for its large dark lilac flowers. In S. Africa, the leaves are considered purgative and a remedy against snake bite (Firminger, 435; Watt & Breyer-Brandwijk, 152).

*I. gracilis* R. Br. is a littoral, twining or prostrate herb, with broadly ovate to oblong, occasionally orbicular to kidney-shaped leaves and funnel-shaped, pink or pink-purple flowers, found on the Indian coast. The plant is useful as a sand-binder [Fl. Malesiana, Ser. I, **4**(4), 470; Burkill, II, 1249].

*I. illustris* (C.B. Clarke) Prain syn. *I. campanulata* auct., non Linn.; *I. campanulata* Linn. var. *illustris* C.B. Clarke (Mar.—*Goili, tugelmi*; Kan.—*Karihuginniyahambu, kuginiballi*) is a large handsome,

showy twiner with cordate-ovate leaves and tubular campanulate, white, purple or rose coloured flowers, purple in the centre, found in Sundarbans, Madras, Saurashtra, Deccan, western ghats, west coast from Konkan to Kerala and Andaman Islands. Young shoots are eaten in curries. Slender stems are used as cordage (Talbot, II, 295).

*I. learii* Paxt., a native of S. America, is a perennial climber introduced into India and grown as an ornamental plant in gardens, on walls and trellises. It is useful as a cover for waste lands and embankments. The root is reported to be used by the Mundas for dysentery (Bor & Raizada, 5; Bressers, 99).

*I. tiliacea* (Willd.) Choisy syn. *I. fastigiata* (Roxb.) Sweet is a scandent twining herb with ovate-cordate, entire or sometimes lobed leaves and funnel-shaped, purple-pink or white flowers, introduced into Bengal. The roots are purgative. Analysis of powdered roots gave the following values: moisture, 71.50; invert sugar, 0.36; sucrose, 0.29; starch, 10.10; cellulose and ash, 12.47; and resins, 4.69%. The roots contain an amorphous glycoside, ipomoein, which has since been shown to be a mixture. On hydrolysis, ipomoein gives methyl-crotonic acid and ipomoenic acid (*Chem. Abstr.*, 1932, **26**, 2488; Wehmer, II, 1012, 1013; Merck Index, 534; Tschirch & Stock, II, 1622).

Several other species are grown in Indian gardens exclusively for their showy flowers. They include *I. hederacea* (Linn.) Jacq. syn. *Convolvulus hederaceus* Linn., *I. horsfalliae* Hook., *I. lobata* (Cerv.) Thell. syn. *I. versicolor* Meissn., *I. macrorhiza* Mich., and *I. tricolor* Cav. syn. *I. rubrocaerulea* Hook. (Firminger, 434, 436; Bor & Raizada, 3–9).

A number of species described under *Ipomoea* in Fl. Br. Ind. & D.E.P. are now transferred to *Calonyction*, *Exogonium*, *Merremia* and *Operculina* (q.v.).

**Ire Rubber** — *see* **Funtumia**

**IRESINE** P. Br. (*Amaranthaceae*)

Fl. Malesiana, Ser. I, **4**(2), 97; Bailey, 1947, II, 1662.

A small genus of herbs or under shrubs, native of tropical or subtropical America, often cultivated in gardens as border or bedding plants for their bright ornamental foliage. Two or three species are grown in India (Firminger, 386; Gopalaswamiengar, 298).

*I. herbstii* Hook. f. syn. *Achyranthes verschaffeltii* Lem. is a small, perennial, much-branched herb, 2–3 ft. high, with bright crimson or maroon coloured leaves. It is propagated by cuttings. The leaves are employed, in Java, for colouring agar-agar jelly; the red colouring matter is obtained by squeezing the leaves in water (Burkill, II, 1251).

**Iridis Rhizoma** — *see* **Iris**

**IRIS** Linn. (*Iridaceae*)

D.E.P., IV, 496; Fl. Br. Ind., VI, 271.

A genus of rhizomatous or bulbous herbs distributed in the north temperate regions of the world. Several species are ornamental; some are cultivated for their rhizomes which constitute the Orris of commerce. About a dozen species occur in India and a few exotics are cultivated for ornament.

Orris, Orris Root or Iridis Rhizoma consists of peeled and dried rhizomes of *I. germanica* Linn., **I. florentina* Linn.=*I. germanica* var. *florentina* Dykes, and *I. pallida* Lam., all perennials found in Europe and the Mediterranean region, but chiefly cultivated in Italy. The rhizomes of the three species resemble one another and occur in commerce as hard, cream-coloured, jointed or branched pieces, 5–10 cm. long and 2–3 cm. broad, dorsiventrally compressed and exhibiting yearly growths of enlargements alternating with constrictions; they have an agreeable aromatic odour and bitter taste, and break with a rough and mealy fracture. The rhizomes of *I. pseudacorus* Linn. and *I. foetidissima* Linn. have also been used in Europe as Orris Root (Youngken, 216–18; B.P.C., 1949, 452).

Orris plants may be readily propagated by seed or by divisions of old rhizomes. They thrive in a variety of soils, but highly fragrant rhizomes are obtained from plants growing in rather dry and gravelly situations. The rhizomes are harvested after about three years, freed from roots and aerial parts, peeled and dried. Fresh rhizomes are odourless and acrid, but during the long process of drying, they lose their acridity and develop the characteristic aromatic odour, reminiscent of violets. Under favourable conditions, a yield of 5–6 tons of dry rhizomes per acre is obtained every third year (Sievers, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1999, 1948, 72; Youngken, 218).

Orris is imported into India from Persia; small quantities are produced in Kashmir. The orris found in the Indian bazaars is usually unpeeled and some-

* The application of the binomial *I. florentina* to this species has been disputed by some authors who hold that *I. florentina* Linn. is synonymous with *I. spuria* Linn. and distinct from *I. florentina* Hort.

what dark in colour; it is less fragrant than European orris (Dymock, Warden & Hooper, III, 451; Nadkarni, I, 694; B.P.C., 1949, 453).

The principal use for orris is as a perfuming and flavouring agent for cosmetics, dentifrices, etc. It has been noted, however, that many persons are allergic to its use and because of this sensitizing property, orris root is rarely recommended at present. The characteristic violet-like odour of dried and aged rhizomes is due to the presence of an essential oil, Orris Oil. The rhizomes also contain a flavone glucoside, iridin ($C_{24}H_{26}O_{13}$; m.p., 217°), sugar, starch, resin, and tannins (U.S.D., 1955, 939; Wehmer, I, 169).

Orris oil occurs in commerce as concrete, absolute (liquid) and resinoids, and is highly esteemed in perfumery. The rhizomes of *I. pallida* are preferred for the extraction of oil; those of *I. florentina* are poor in oil content while the oil from *I. germanica* is of inferior quality. Steam-distillation of the roots yields (0.2–0.4%) Concrete of Orris, a solid mass of yellow colour, with a pleasant, violet-like odour and the following constants: m.p., 40–45°; acid val., 162–216; ester val., 4–36; and neutral fraction, 13–25.5%. Elimination of fatty acids, chiefly myristic acid, which forms 83–96% of the concrete, results in Absolute of Orris, a viscous, yellow to brownish liquid with a strong but pleasant odour, characteristic of orris root. It has the following range of constants: sp. gr.$^{15°}$, 0.922–0.942; $n^{20°}$, 1.4862–1.4985; $[\alpha]_D$, +20.1° to +36.5°; sap. val., 22.0–64.4; acid val., up to 7.4; sol. in 0.5 vol. of 90% alcohol; and ketone content, 52.8–73.5%. Resinoids of Orris are obtained from the rhizomes by extraction with volatile solvents; removal of fatty acids results in Absolute Resinoids. Orris oil owes its fine aroma to the presence of unsaturated isomeric ketones, irones; absolute of orris and absolute resinoids consist mainly of irones (Guenther, VI, 79–98; *Perfum. essent. Oil Rec.*, 1947, **38**, 381).

Orris concrete is blended with ionone and used as a base for violet compositions: it is also useful in other floral ottos of this type; it imparts strong, lasting and alluring notes. The absolute is one of the most valuable and expensive perfumes used in preparations where a high solubility in alcohol is required. Resinoids of orris are fixatives and find use in high class soaps, cosmetics, dentrifices, etc. Orris oil is used also for flavouring soft drinks, candies and gelatine desserts. Extracts of iris bulbs are employed in meat curing pickle solutions to prevent food poisoning (Poucher, I, 316; Guenther, VI, 104; Kirk & Othmer, IX, 586; *Chem. Abstr.*, 1951, **45**, 7723).

Orris oil is adulterated occasionally with cedar oil, gurjun balsam and myristic acid. Orris absolute is adulterated by ionones and esters of myristic acid (Gildemeister & Hoffmann, II, 270; Guenther, VI, 93).

Orris possesses stimulant, cathartic and diuretic properties, and is used in bronchitis, dropsy and liver complaints; as powder or in poultice, it is applied to sores and pimples (Nadkarni, I, 694–95).

*I. ensata* Thunb. (HINDI—*Irisa, sosun*; KASHMIR—*Marjal, unarjal*) is a perennial herb occurring in western Himalayas at altitudes of 5,000–9,000 ft. Rootstock stout, creeping; stems tufted, up to 2 ft. high; leaves linear; flowers lilac or white; spathe 3–4 in. long; capsule 6-ribbed, beaked.

The root of *I. ensata* is reported to possess alterative properties and it is employed as an ingredient of compositions for purifying blood and for venereal diseases. It is also useful in liver complaints and dropsy. The leaves are used as fodder, for thatching, matting and basket work. The plant is reported to give a high yield of fibre (Kirt. & Basu, IV, 2460; *Plant Breed. Abstr.*, 1955, **24**, 97).

The fresh flowers of this plant contain 0.05–0.1% of an anthocyanin pigment, ensatin chloride ($C_{38}H_{41}O_{19}Cl.10H_2O$; m.p., 175° decomp.). The pigment on hydrolysis yields glucose, malvidin chloride ($C_{17}H_{15}O_7Cl$) and *p*-hydroxy cinnamic acid (McIlroy, 56; *Chem. Abstr.*, 1941, **35**, 1786).

*I. kumaonensis* Wall. (PUNJAB—*Karkar, tezma*) is a perennial herb occurring in the western Himalayas, from Kashmir to Kumaon, at altitudes of 8,000–12,000 ft. Rootstock thick, creeping; stems up to 1 ft. high; leaves linear; flowers bright lilac; spathe 2–3 in. long, often enveloped by the uppermost leaf; capsule 1–2 in. long, ovoid. The roots and leaves of this plant are reported to be used in Chamba for fever; leaves are useful as fodder.

*I. nepalensis* D. Don (HIMALAYAS—*Chalnundar, chiluchi, shoti, sosan*) is a perennial herb occurring throughout the Himalayas and in Khasi hills at altitudes of 5,000–10,000 ft. Rootstock stout, prostrate, with densely fibrous sheaths and copious, fleshy, finger-like roots; stems slender, up to a foot high; leaves linear, up to 2 ft. long; flowers pale lilac; spathe 1.5–2 in. long; capsule oblong, enclosed in persistent spathes.

The root of *I. nepalensis* is reported to possess diuretic, aperient and deobstruent properties and is

considered to be especially useful in removing bilious obstructions. It is also used as an application to sores and pimples (Kirt. & Basu, IV, 2461).

A few species of *Iris* have been introduced into India and grown in gardens in hill stations. They thrive well on rich sandy soil containing leaf mould and well rotten cattle manure. The rhizomes used for propagation should not be kept out of the soil for long and planting should not be too deep. The plants blossom in 2–4 years. *I. germanica* and *I. florentina* are popular in hill gardens, particularly in Kashmir. The former is a rich source of ascorbic acid. The concentration of ascorbic acid in different parts of the plant is as follows: leaves, 486; blossoms, 420; buds, 496; base of buds, 604; and roots, 87 mg./100 g. Extracts of leaves containing ascorbic acid, and possibly vitamin P, have been employed for the treatment of frozen feet. The leaves also contain $\beta$-carotene and traces of $\alpha$-carotene (Gopalaswamiengar, 493; *Chem. Abstr.*, 1942, **36,** 6198; 1947, **41,** 5584; 1940, **34,** 4425; Deuel, I, 519).

**Iroko** — *see* **Chlorophora**

## IRON ORES

Next to aluminium, iron is the most abundant metallic element, comprising about 4.44% of the earth's crust. It does not occur in the metallic form, except rarely in meteorites. It is found mainly in the form of oxides (e.g. magnetite and hematite), hydrated oxides (e.g. limonite), carbonates (e.g. siderite), sulphides (e.g. pyrite, chalcopyrite and pyrrhotite), silicates (e.g. chamosite and greenalite) and hydrated oxides of iron and aluminium (e.g. laterites). Chromite and ilmenite are also iron-bearing minerals.

Only a few of the iron-bearing minerals are exploited for the extraction of metallic iron. These are magnetite, hematite, limonite, siderite and rarely laterite. Iron is sometimes obtained as a by-product in the working of pyrites and ilmenite.

Magnetite ($Fe_3O_4$; Fe, 72.4%; sp. gr., 5.17–5.18; H., 5.5–6.5) is the black magnetic oxide of iron. It is of igneous, replacement or metamorphic origin and occurs in large masses. It is isometric, the commonest crystal form being the octahedron. In the form of loadstone, magnetite is sometimes used as a magnet.

Hematite ($Fe_2O_3$; Fe, 70%; sp. gr., 4.9–5.3; H., 5.5–6.5) is the red oxide of iron. The crystalline rhombohedral form (specular hematite) may be nearly as black as magnetite, but its cherry-red streak and non-magnetic character distinguish it from magnetite. When earthy or granular, it is red. Large ore bodies of sedimentary origin (e.g. banded hematite-jasper) occur extensively: some ore bodies are of replacement origin.

Limonite, the brown ore of iron, was formerly considered to include a series of hydrated ferric oxides. It is now known to consist of only ferric oxide monohydrate ($Fe_2O_3.H_2O$; Fe, 59.8%) and contains adsorbed and capillary water. It occurs in amorphous form (limonite) and crystallizes in the orthorhombic form (goethite and lepidocrocite). Lepidocrocite (sp. gr., 4.09) has a red colour and goethite (sp. gr., 4.28) is yellowish brown. Limonite and the crystalline monohydrates may have been derived from surface weathering of iron-bearing sulphides, iron-bearing silicates or iron carbonates. They are less hard than hematite and contain 10–14% combined water.

Siderite ($FeCO_3$; Fe, 48.2%; sp. gr., 3.83–3.88; H., 3.5–4) is commercially known as spathic iron. It is dark brown to black in colour and crystallizes as rhombohedra in the hexagonal system. Siderite occurs as sedimentary or replacement deposits, sometimes associated with other carbonates like calcite. Though siderite contains less iron than hematite, it is self-fluxing and is therefore considered a very desirable ore for metallurgical purposes. Its grade may be raised to that of hematite by calcination.

Laterites (iron and aluminium hydroxides) are porous brown hydrated iron oxide rocks, turning dark and hard at the surface. Large workable deposits occur especially in the Philippines, Cuba and Indonesia. The iron content of the ore is low and some of the deposits contain deleterious impurities. Laterite is not worked as ore at present except in Cuba.

Ilmenite ($FeO.TiO_2$; Fe, 36.8%; sp. gr., 4.5–5; H., 5–6) is iron-black with a black to brownish streak. It has a variable iron-titanium ratio. It is not an important iron ore; in Canada iron is obtained from it as a by-product of titanium extraction.

Pyrite ($FeS_2$; Fe, 46.6%; sp. gr., 5.0–5.1; H., 6–6.5) is of golden yellow colour with metallic lustre. It is not usually considered an iron ore, but roasted pyrite residues, after the extraction of sulphur, are commonly sintered along with iron ore fines or other materials for use in blast furnaces.

The chemical composition and physical condition of iron ores influence the character and effectiveness of processes for recovering iron. Thus, based on the treatment required before smelting, iron ores are classified into: (*i*) direct shipping ores which can be

used directly after mining and sizing (e.g. magnetite and hematite); (*ii*) concentrating ores which have to be beneficiated before use (e.g. siderite and limonite); and (*iii*) by-product ores from which iron is obtained as a by-product (e.g. ilmenite and pyrite). Estimates of world reserves of iron ores are summarized in Table 1. Table 2 gives the production of iron ore during 1954–1956 in important producing countries.

The iron content of workable iron ore deposits varies considerably in different parts of the world. Compared to most producing countries, the quality of iron ores mined in India is superior (Table 2). Indian iron ore deposits are among the finest and largest in the world, the average ore worked at present containing over 60% iron.

Hematite is the most important ore used for the production of iron and steel. In India, large deposits of hematite occur in Bihar, Orissa and Madhya Pradesh, and only the ores containing 55-65% iron are at present utilized for smelting. Large deposits of magnetite and limonite also occur in India, but these are not exploited at present.

Consistent with the progress of the iron and steel industry in India, the output of iron ore has gone up from 3.66 million tons in 1951 to 5.07 million tons in 1957. The production is expected to go up to over 15 million tons per annum by 1960-61 to meet the expanded demands of the existing steel plants, as well as those of the new steel plants under erection. At present, Bihar and Orissa between them account for about 85% of the total iron ore production in India. Nearly 75% of the output is smelted; the rest is exported.

TABLE 1—WORLD RESERVES OF IRON ORES*

(million tons)

| Region | Reserves | Iron content |
|---|---|---|
| North America & West Indies | 14,100 | 6,600 |
| South America | 19,700 | 10,000 |
| Europe (excluding U.S.S.R.) | 16,480 | 6,400 |
| U.S.S.R. | 3,200 | 1,900 |
| Africa | 4,100 | 2,000 |
| Asia & Middle East† | 26,000 | 14,300 |
| Oceania | 1,000 | 500 |
| Total | 84,580 | 41,700 |

* *Survey of World Iron Resources: Occurrence, Appraisal and Use*, United Nations, Dep. Econ. & Social Affairs, 1955, 34.
† Including 21,000 million tons in India.

TABLE 2—PRODUCTION OF IRON ORE IN PRINCIPAL PRODUCING COUNTRIES*

(thousand tons)

| | 1954 | 1955 | 1956 | Approx. iron content (%) |
|---|---|---|---|---|
| Algeria | 2,869 | 3,528 | n.a. | 55 |
| Austria | 2,670 | 2,787 | 3,187 | 30 |
| Brazil† | 1,646 | 2,513 | n.a. | 65 |
| Canada†† | 6,668 | 14,618 | 19,569 | 55 |
| France | 42,948 | 49,321 | 51,626 | 35 |
| W. Germany | 9,514 | 11,148 | 11,972 | 30 |
| India | 3,916 | 4,245 | 4,187 | 65 |
| Japan‡ | 1,598 | 1,527 | 1,873 | 55 |
| Sweden | 15,018 | 17,005 | 18,675 | 60 |
| U.S.S.R. | 63,034 | 70,442 | 76,440 | 60 |
| U.K. | 15,488 | 16,111 | 16,241 | 30 |
| U.S.A.** | 77,569 | 104,523 | 96,879 | 50 |

* *Mineral Production in India*, Indian Bureau of Mines, 1956, 73.
† Exports; †† Shipments including Newfoundland; ‡ Including iron sand; **Excluding manganiferous iron ores containing 5% and above of manganese
n.a.—Not available

### Origin and Mode of Occurrence

Only a few of the world's iron ore deposits are of igneous origin. The great majority of them have been formed by deposition from surface or underground waters, the iron being normally derived by solution from pre-existing rocks under ordinary temperature conditions. In some cases, the iron minerals have been concentrated in the form of iron sands. Certain important lateritic ores in Cuba, Borneo and the Philippines are of residual origin.

The deposition of iron carried in solution may be caused by displacement, e.g. iron solutions traversing limestone beds may take lime carbonate into solution and deposit iron carbonate, the latter replacing the dissolved limestone. Evaporation and consequent saturation may also cause deposition of dissolved iron compounds. Electrolytes occurring in natural waters may also precipitate iron.

The iron ores of India can be divided into three major groups according to their origin. The first and the most important group comprises the banded hematite-jasper formations of pre-Cambrian age. In the unmetamorphosed type, which includes the majority of the larger deposits (Mysore, Sandur and

Goa in South India and Bihar, Orissa and Madhya Pradesh in North India), the ore bodies have been derived by the enrichment of banded ferruginous rocks through the removal of silica. The ore bodies generally form the top of ridges and hillocks and are often of great magnitude. Most of them contain high grade ores (over 60% iron) near the surface associated with large quantities of lower grade ores. Where metamorphosed, the hematite-jaspers have been converted into banded quartz-magnetite rocks in which the magnetite is derived from the original hematite. These latter ores are of low grade (35–40% iron), owing to their association with quartz but are amenable to concentration.

The second group consists of sedimentary iron ores of sideritic or limonitic composition. Examples of such ores are ironstone shales of the eastern coalfields of Bengal and Bihar and the ferruginous beds occurring in the Tertiary formations in parts of the Himalayas and Assam. The sideritic ore is often hydrated and changed to limonitic ironstone near the surface.

The third group consists of lateritic ore derived from the subaerial alteration of iron-bearing rocks, such as gneisses, schists and basic lavas, under humid tropical conditions, resulting in the concentration of hydrated oxides of iron, often associated with those of aluminium and manganese. Lateritic caps cover large stretches of the Deccan Trap, the gneisses in western ghats, the schistose rocks of many areas (e.g. Sandur in Mysore State) and impure limestone formations.

In addition, iron ore deposits of igneous origin also occur in India, e.g. the apatite-magnetite rocks of Singhbhum copper belt and the titaniferous and vanadiferous magnetites of south-east Singhbhum, Keonjhar, Mayurbhanj and south Mysore. Mention may also be made of the lode deposits of hematite, possibly of hydro-thermal origin, which occur in Veldurti and Ramallakota in Kurnool district, Andhra State. These deposits are, however, not of great importance (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 14, 102).

The geological formations, the types of ores found in them, and the regions in which such deposits occur are given in Table 3.

### Distribution

Iron ores occur practically in every State in India but richer deposits are found mainly in Bihar, Madhya Pradesh, Orissa, Bombay, Mysore, Madras and Andhra.

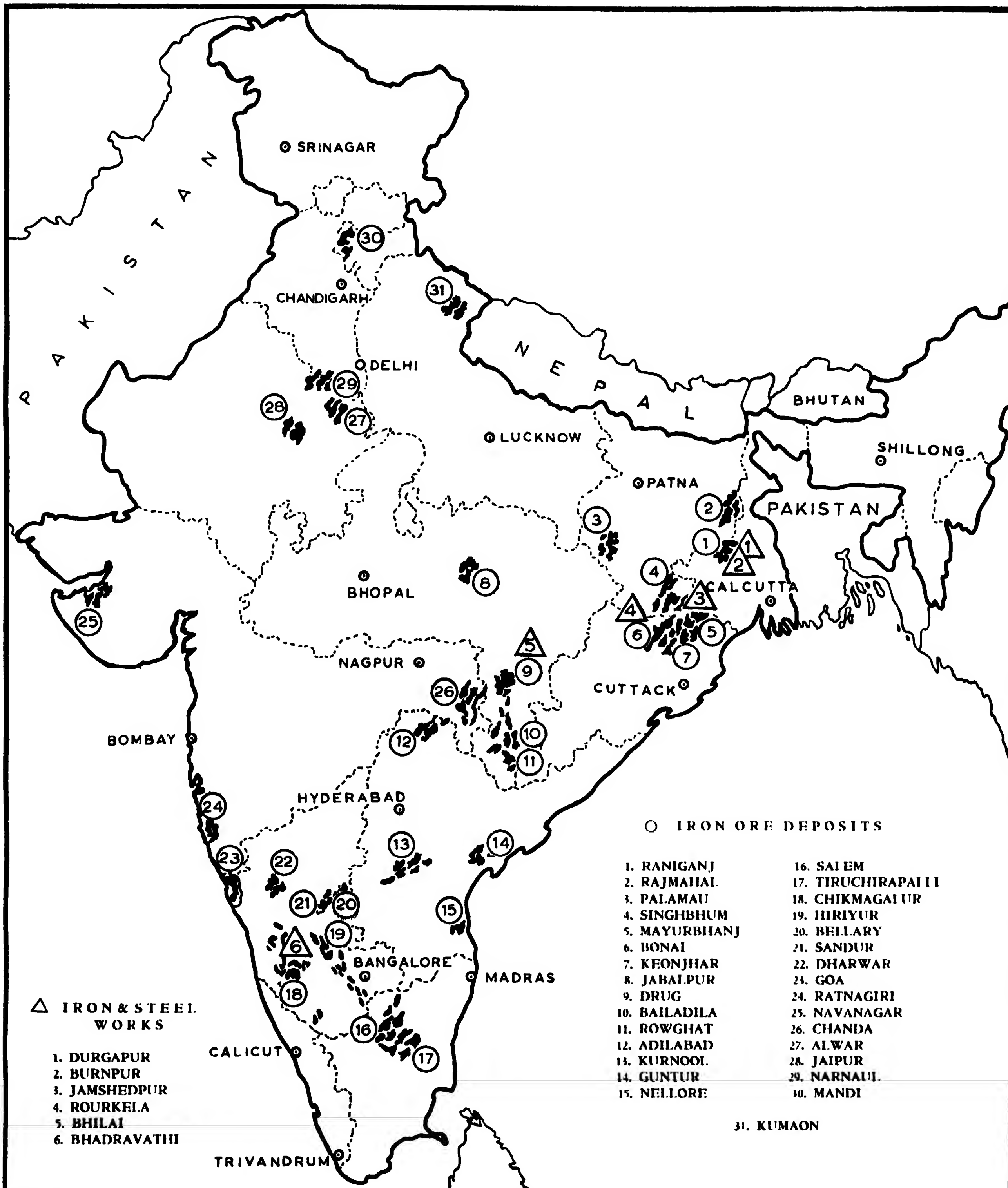
#### Andhra

*Cuddapah district*—Hematite occurs in an area about 1 mile south of Chabali (14°30′:78°36′). The ore, shaly in texture and chocolate-coloured, is distributed in shallow patches. The largest patch, west of Sallaneelu Kunta, is estimated to contain 40,000

**TABLE 3—GEOLOGICAL DISTRIBUTION OF INDIAN IRON ORES[1]**

| Formation | Nature of ore | Occurrence |
|---|---|---|
| *Pre-Cambrian* | | |
| Basic & ultra-basic rocks | Titaniferous & vanadiferous magnetites | Bihar S.E. Singhbhum<br>Orissa Mayurbhanj<br>Mysore Southern districts |
| Granodiorite | Apatite-magnetite rocks | Bihar Singhbhum<br>Orissa Mayurbhanj |
| Granite | Magnetite (residual) | Assam Jaintia hills<br>Bihar Singhbhum<br>Orissa Bonai, Keonjhar, Mayurbhanj<br>Mysore—Shimoga, Chikmagalur, Dharwar, Sandur |
| Banded iron formations | Hematite (massive, shaly, powdery, etc.) | Bombay Ratnagiri<br>Madhya Pradesh—Bastar, Chanda, Drug, Jabalpur |
| Banded iron formations (metamorphosed) | Magnetite-quartzites | Madras Salem, Tiruchirapalli<br>Mysore Shimoga<br>Himachal Pradesh Mandi<br>Andhra Guntur |
| *Cuddapah* | | |
| Bijawar<br>Gwalior | Hematite & ferruginous quart | Madhya Pradesh Gwalior, Indore, Bijawar, Rewa<br>Andhra Cuddapah |
| *Gondwana* | | |
| Barakar<br>Mahadeva | Ironstone & siderite | Bengal Birbhum<br>Bihar Auranga coal-field |
| Ironstone shales | do. | Bengal Raniganj coal field |
| *Triassic* | Hematite & limonite | Kashmir |
| *Jurassic* | | |
| Rajmahal Trap (inter-Trappean beds) | Ironstones | Bengal Rajmahal<br>Bihar Birbhum |
| *Tertiary Miocene & Eocene* | Ironstones | Kerala—Travancore, Malabar<br>Assam—N.E. districts<br>Uttar Pradesh Kumaun |
| *Quaternary* | Laterite | All States—derived from many formations including Deccan Traps |

[1] Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 108.




DISTRIBUTION OF IRON ORE DEPOSITS AND LOCATION OF STEEL WORKS IN INDIA

tons of ore within a depth of 20 ft. Near Pagadalapalle (14°17′:78°37′), smaller patches of iron ore of the same type occur. The deposits are not extensive. Being soft, a large part of the ore can be used as paint pigment (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 142).

*Guntur and Nellore districts* Both magnetite and hematite bearing schists occur in these districts. There are two groups of occurrences—the Ongole group and the Gundlakamma group. The Ongole group occurs 15 miles north of Singarajakonda (15°52′: 79°59′) and comprises 4 deposits, viz. the Ongole beds, Keonijedu-Marlapadu beds, Peruametta beds and Sanampadi beds. The first three lie in Guntur district and the last one in Nellore district. The reserves of ore (33–37% iron and 40–50% silica) in these deposits are estimated at 293 million tons. The ore is not suitable for direct smelting but is amenable to beneficiation (*Indian Tr. J.*, 1957, **200,** 4).

The Gundlakamma group consists of 4 or 5 subgroups stratigraphically related, but geographically separated from each other. Among these, the Burapalle subgroup consisting of two thick and fairly rich beds exposed at Tammavaram hill (15°41′: 81°0′) is perhaps the richest; the Maniksevaram (15°45′:79°59′) band which is more than a mile long and located about 1½ miles N.N.W. of Burapalle is another The third subgroup appears as a group of 5 beds exposed on the hills 2 miles north of Addanki. Three of these are fairly rich in iron and form the Singarajakonda (15°52′:79°59′) deposit. Four miles N.W. of Singarajakonda 4 other bands are seen. Several beds of hematite schists interlaced with micaceous and flaggy schists occur in Chundi hills but only 2 or 3 of them seem to be fairly rich in hematite. There are also some banded hematite-quartzites and hematite schists in the southern part of Nellore district extending between Ircola (13°48′:79°58′) and Tresalmare (13°51′:79°54′) (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 145).

*Kurnool district*—A series of deposits of high grade hematite, often siliceous, occurs between Veldurti (15°33′:77°56′) and Ramallakota (15°34′:78°1′). The ore is of good quality, partly specular in character, and also jaspery where it is siliceous. The ore bodies are lens-like when large and form veins and stringers in the fault zone. The reserves of the deposits are estimated at 3.7 million tons up to a depth of 100 ft. (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 145).

In the north-eastern districts of the former Hyderabad State, which now form part of Andhra, there are a few hematite-magnetite deposits, usually highly siliceous. The chief deposits lie between latitudes 18°40′ and 19°20′ and between longitudes 78° and 79°, near the junction of the districts of Adilabad, Karimnagar and Nizamabad. The banded formations vary in thickness between 50 ft. and 150 ft., the maximum thickness (150 ft.) being found in the Chityal hills (19°5′:78°45′). These ores contain on an average 40% iron and the reserves are estimated at 32 million tons.

In Warangal district, south of Singreni coalfields, occurs a band of ironstone consisting of magnetite-quartz schists containing 40% iron. The quantity of ore in this area has been estimated at 5.5 million tons. There is also a group of deposits near Tawargera (15°45′ : 76°20′) in the south-west part of Raichur district.

There are large spreads of laterite in Bidar and Vicarabad plateaus which, though highly ferruginous, are too high in alumina to be considered suitable for exploitation at present. They contain 20–40% iron and some titanium (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 160).

### Assam

*Lakhimpur and Sibsagar districts*—Iron ores are found in two groups of geological formations: in the Eocene coal measures as clay ironstones and in the Tipam series (Miocene) as impure sandy limonite bands in shales and sandstone beds. The former contains spheroid nodules of varying sizes segregated along thin bands in a group of interstratified shales and sandstones: the nodules occasionally cement together into a conglomerate. The clay-ironstones (Fe, 20–40%) are of no importance at present. The ore from the Tipam series is also of poor quality (Fe, 25–40%).

In the Khasi and Jaintia hills, deposits of magnetite derived from the decomposition of granite masses occur over an area of 12 sq. miles, about 18 miles north of Cherrapunji. These were worked for about 40 years during the latter half of the nineteenth century (Krishnan, *Indian Minerals*, 1952, **6,** 120).

### Bihar and Orissa

*Palamau district*—Clay-ironstones and hematite occur at Rajbar (23°47′:84°39′) as strings of nodules in a zone of ferruginous shales. The average iron content of the analyzed samples was 44.8%. Similar ore occurs north of Balunagar (23°50′:84°41′) and

near Morwai (23°46′: 84°7′). Near Daltonganj, magnetite occurs in two groups of deposits, one near Gore (23°38′: 83°58′) at the top of 4 hillocks and the other near Biwabathan (23°55′: 84°3′). The ore consists mainly of magnetite which has been partially replaced by hematite. The reserves near Gore have been estimated at 400,000 tons of good grade magnetite of 55–60% iron. Biwabathan ore has an average iron content of 60% (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 116).

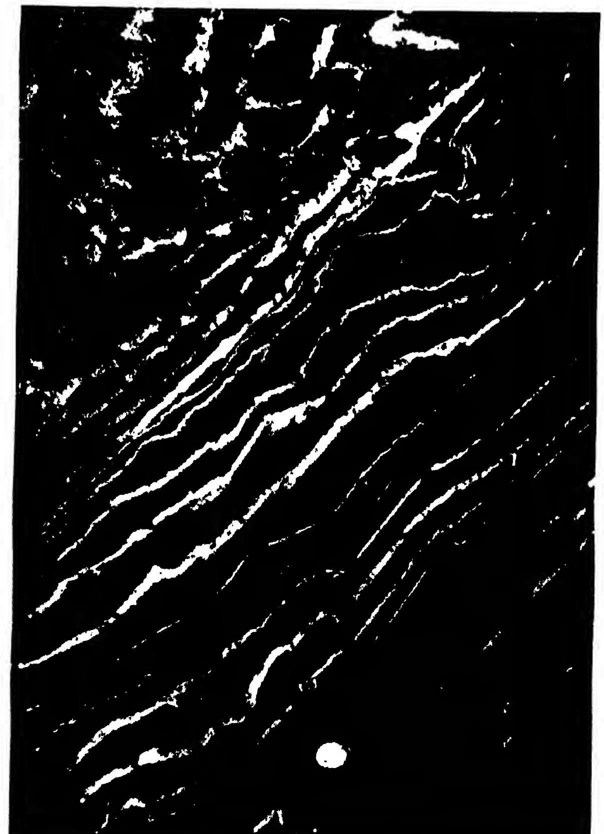
*Singhbhum district*—A zone of apatite-magnetite rock is found closely associated with the copper belt of Singhbhum, especially between Dhadkidih (22°45′: 86°6′) and Khejurdari (22°24′: 86°34′) in south-east Singhbhum. The rock also contains biotite, chlorite and very subordinate quartz. It forms lenses of varying sizes from a few inches to a few feet thick and of varying lengths. The principal mineral present in the rock is apatite and the relative proportions of apatite and magnetite vary considerably from place to place. Magnetite is abundant in the rocks near Patharghara (22°32′: 86°27′). Large lenses are found at or near Kunharia (22°44′: 86°9′), Ramchandra pahar (22°43′: 86°12′), Kanyaluka (22°29′: 86°31′), Badia (22°29′: 86°28′) and Sunrgi (22°27′: 86°27′). The deposits are comparatively small and of not much importance at present.

*Singhbhum and Mayurbhanj districts*—In south-east Singhbhum and the adjacent parts of Mayurbhanj to the south and south-west of the copper belt, there are a few deposits of titaniferous magnetite which often contain vanadium in the form of microscopic inclusions of coulsonite (iron-vanadium oxide). Occurrences are known around Dublabera (22°29′: 86°17′), Sindurpur (22°28′: 86°15′), Kumhardubi 22°17′: 86°19′), Bet Jharan (22°16′: 86°19′), Kaduani (22°17′: 86°21′), Kudada (22°42′: 86°12′), Pora pahar and Kotwar pahar. Only an approximate idea of the distribution has been possible as the region is covered by thick jungles, soil and rock debris.

The ore occurs as veins, lenses and pockets in gabbroid and ultra-basic igneous rocks, but they do not form conspicuous outcrops. The deposits contain mostly titaniferous magnetite (sp. gr., 3.8–4.8; $TiO_2$, 10–25%; $V_2O_5$, 2–7%) and in many cases appreciable amounts of hematite. The Kumhardubi deposit is the largest so far known, the reserves of the ore at the surface being estimated at 1 million tons. Data on the other deposits are not available. Preliminary reconnaissance in the Simlipal area of Mayurbhanj district indicates the presence of similar deposits of magnetite ore (Dunn & Dey, *Trans. Min. geol. Inst. India*, 1937, **31**, 117–83).

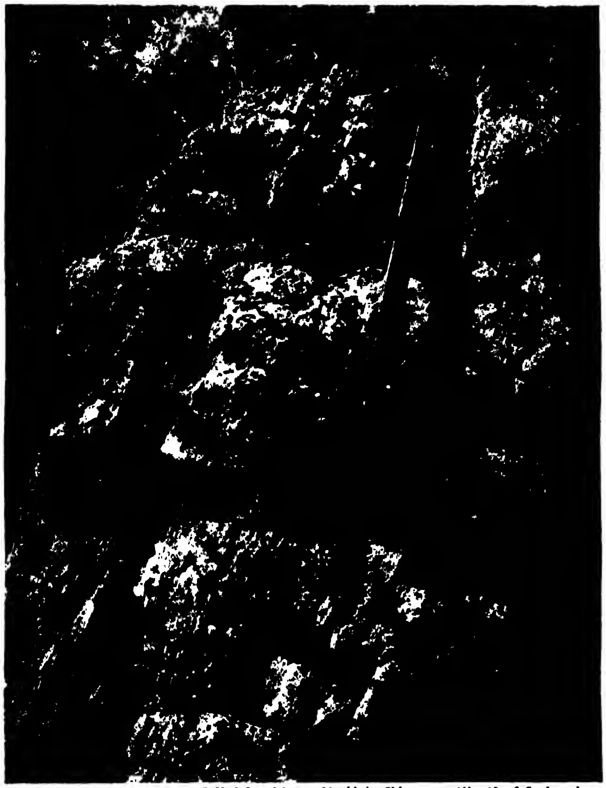
*Singhbhum-Keonjhar-Bonai districts*—The most important deposits of iron ore in India occur in south Singhbhum and the adjoining districts of Bonai and Keonjhar in Orissa within the area bounded by north latitudes 21°41′ and 22°20′ and east longitudes 85°5′ and 85°32′. The deposits consist of unmetamorphosed pre-Cambrian sedimentary iron ores of the banded quartzite type. They form part of a pre-Cambrian sedimentary sequence known as the Iron Ore Series and are associated with basic volcanics and pyroclastics and are overlain by sandstones, conglomerates and lava. The rocks of the Iron Ore Series have a general north-north-east to south-south-west strike.

The banded ferruginous rocks consist of alternating bands of hematite and quartz, the latter being jaspery. In the jasper bands the silica may be chalcedonic or micro-crystalline. The hematite-jasper bands are coloured in various shades of yellow, red or brown, according to the amount of iron present. The



*I.B.M., New Delhi. Photo: N. Sen*

FIG. 138. MASSIVE IRON ORES—ALTERNATE BANDS OF BLUE DUST AND SHALE (GUA)



*I.B.M., New Delhi. Photo : T. C. Mukerjee*

FIG. 139. MASSIVE IRON ORES (BONAI)

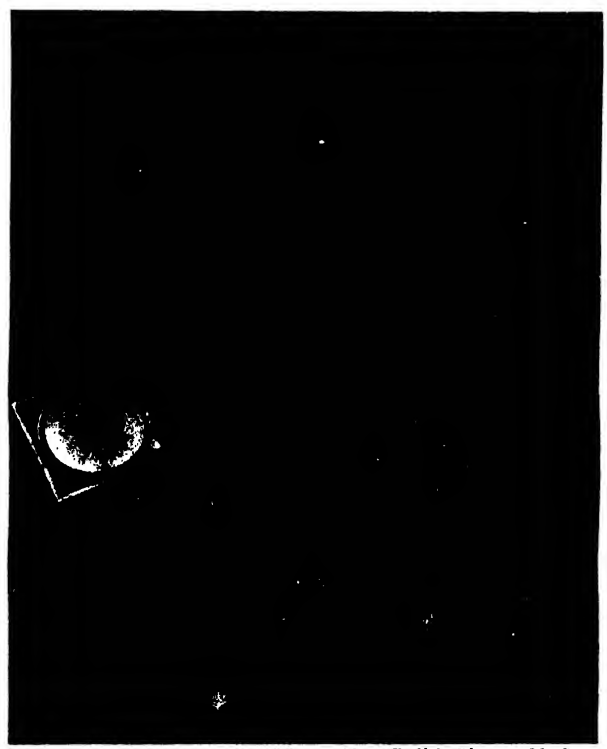
hematite bands often stand up due to their greater hardness, while the jasper bands which are partly leached out form depressions. The individual layers vary considerably in thickness (av., 0.05 in.). The thickness of the ore bodies is in many places 1,000 to 2,000 ft., and occasionally up to 3,000 ft. In south Singhbhum, Keonjhar and Bonai, the hematite-jasper bands form prominent ridges rising to 2,500–3,000 ft. The lower ground is occupied by phyllites, lava and shales. In some places in Bonai and Keonjhar districts the phyllites have been partly replaced by manganese ores.

The banded hematite-jasper is frequently seen to change laterally into hard massive ore, or into the laminated variety with a shale-like appearance, or into the powdery variety. These varieties having different physical properties are described as massive, laminated, shaly and powdery ores. The most common type is the massive ore which is hard, compact and dark brown to brownish black. It is commonly found on tops of ridges, sometimes extending downwards to 50–100 ft. It weathers into large (1–2 cu. yd.) rugged blocks with a smooth polished surface. Massive ore (sp. gr., *c.* 5.0) contains 68–70% iron.

The laminated ore possesses a series of laminations, sometimes with open spaces between them, partly or wholly filled up by powdery ore or by a shaly substance. The quantity of this ore is much more than that of the massive ore. The laminated ore is less dense and poorer in iron content (55–60%) than the massive ore. It may be made richer by breaking up and screening the interstitial powdery material.

The shaly ore generally occurs at some depth in the workings ; it has a shale-like texture with a silky or satiny lustre. Some samples are rich (68–70% iron) while others are comparatively poor (60% iron) and contain siliceous and aluminous matter intercalated between the layers.

The powdery ore is found as small lenses and patches in workings and consists of thin bedded crystalline material of blue-black colour. When *in situ*, it shows bedding and may contain lumps of laminated ore within it, but becomes powdery with the slightest disturbance. Sometimes it has a micaceous appearance owing to the particles being minute flat flakes of specular hematite. It consists mainly of



*I.B.M., New Delhi. Photo N. Sen*

FIG. 140. LAMINATED IRON ORES (BONAI)

hematite, occasionally mixed with martite, and is fairly rich in iron (66–69%), but so far no attempt has been made to sinter it for use in blast furnaces.

In addition to the above major types, there is also a gritty, conglomeratic and brecciated type of ore formed by the binding together of ore pieces by secondary limonite. This type of ore is usually of high grade (over 60% iron) (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 133).

The most conspicuous groups of deposits of the Singhbhum-Keonjhar-Bonai region form a hill range about 30 miles long, from a point about 3 miles south-west of Gua (22° 13′ : 85° 23′) in Singhbhum district to near Rontha (21° 46′ : 85° 8′) in Bonai district. This range is capped in most parts by massive hematite which is continuous, except for short breaks at 3 or 4 places. There are also 3 or 4 parallel ranges beyond and north of Gua which are also capped by high grade ores. Other large deposits in this area include Budha Buru east of Ankua (22° 18′ : 85° 16′), Raijori Buru west of Gua, Kotamati Buru where Noamundi mines (22° 9′ : 85° 28′) are situated, Thakurani pahar (22° 6′: 85° 26′), Bara pahar and Banspani pahar near Joda (22° 1′: 85° 26′), and the hills near Kurband (21° 57′:85° 24′).

The chief operating mines in this area are the Noamundi iron mine of the *Tata Iron & Steel Co. Ltd.*, the Gua and Manoharpur mines of the *Indian Iron & Steel Co. Ltd.*, and the mines of *Bird & Co.*, near Barajamda (22° 10′: 85° 25′). The size of some of the larger ore bodies of the region can be roughly followed by the estimates made by the Geological Survey of India nearly 30 years ago (Table 4). These estimates have been revised and the total resources of high grade ores of Singhbhum-Keonjhar-Bonai region are now estimated at 8,000 million tons (Percival, *Trans. nat. Inst. Sci. India*, 1947, **2**, No. 8).

*Mayurbhanj district*—Hematite deposits of large magnitude occur in the following places: Gorumahisani hill; Sarandapir, close to Bandgaon; Sulaipat-Badampahar range, extending over a distance of 12 miles from Kondadera to Jaidhanposi; Simlipahar

*I.B.M., New Delhi. Photo : P. K. Ghosh*

FIG. 141. MASSIVE IRON ORES (NOAMUNDI MINE)

TABLE 4—ESTIMATED RESERVES IN SINGHBHUM-KEONJHAR-BONAI REGION*
(million tons)

| | Qty |
|---|---|
| Main iron ore range | 1,875 |
| Budha Buru | 145 |
| Pansira Buru | 10 |
| Kotamati Buru | 180 |
| Pachri Buru | 66 |
| Thakurani pahar | 256 |
| Bara pahar | 122 |
| Banspani pahar | 50 |
| Sidhamat pahar | 25 |
| Kurband & Satkutnia hills | 48 |

* Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 136; Jones, *Mem. geol. Surv. India*, 1934, **63**(2), 250 60.

range and a tract to the east; and several localities from Kamdabedi to Thakurmunda, over a distance of 25 miles.

The Gorumahisani hill (22° 19′: 86° 18′; height, 2,964 ft.) is made up of banded hematite-quartzites associated with quartzites, epidiorites and grunerite bearing rocks. The banded hematite-quartzite consists of alternating thin layers of hematite and quartz or jasper and occupies the eastern part of the hill, which is capped on the north and east by ore bodies. The top of the hill shows a lateritic capping, while a patch of solid ore occurs in the south-western parts. The ore is of two types—a massive hard hematite and less compact lateritic hematite. The hard ore appears to grade into banded grunerite bearing rock, which is often rich enough in iron to be considered as the ore. On the top of the hill there is much detrital ore which has been worked to-date; some workable deposits of this ore also occur on the north-western slopes. The patch of lateritic ore on the top of the hill, extending down the northern and southern sides, covers an area of 17.5 million sq. ft. The hill was originally reported to contain about 10 million tons of iron ore, but nearly 13 million tons have actually been mined, and a further survey by the *Tata Iron & Steel Co. Ltd.* revealed the existence of about 19 million tons. The average iron content of the ore so far worked is 62–64%. A typical analysis of the solid ore is as follows: Fe, 64.33; $SiO_2$, 1.64; P, 0.075; and S, 0.021% (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 126).

The Sulaipat or Okampad deposit (22° 9′: 86° 15′) forming a peak (2,535 ft.) in the Sulaipat range, 12 miles south-south-west of Gorumahisani hill, is comparatively small. The ore is of high grade (Fe, 69.05; $SiO_2$, 0.90; Mn, 0.09; and P, 0.016%). Up to 1950, 3.5 million tons have been worked; the remaining reserves are estimated at less than one million tons.

The Badampahar deposits (22° 4′: 86° 9′), are about 8½ miles south-west of Sulaipat. The hill contains a series of ore bodies covered with a large amount of float ore, which was the only ore worked until recently. The ores are of variable composition, the average being poorer in iron than that from Gorumahisani or Sulaipat, but generally more porous and well suited for the blast furnace. The average ore contains: Fe, 55.0; $SiO_2$, 7.5; and $Al_2O_3$, 2.8%. A light-weight yellow ore (Fe, 66.6; $SiO_2$, 0.72; $Al_2O_3$, 0.42; P, 0.062; and S, 0.15%), possibly derived from the alteration of basic igneous rocks, is now being utilized. Up to 1950, over 8 million tons of ore have been extracted, and the remaining reserves are estimated at 32 million tons (Bose, *Rec. geol. Surv. India*, 1904, **31**, 168; Percival, *Trans. nat. Inst. Sci. India*, 1947, **2**, No. 8; Krishnan, 1955, 91).

All these deposits are worked by the *Tata Iron & Steel Co. Ltd.* The reserves in the leased areas are estimated at 60 million tons, but there are probably some lower grade ores in the Badampahar area (*Survey of World Iron Ore Resources: Occurrence, Appraisal and Use*, United Nations, Dep. Econ. & Social Affairs, 1955, 278).

Bombay

Iron ore deposits are found in the pre-Cambrian formations in Chanda, Ratnagiri and Navanagar districts of Bombay State and also in Goa.

*Chanda district* Iron ore deposits occur in the northern part of the district in a series of lenses which rise into small hillocks. The strata are of pre-Cambrian age and consist of a series of schists and banded hematite-quartzites, the latter having been enriched to iron ore in places. The major occurrences are at Lohara (20° 23′ : 79° 44′), Pipalgaon (20° 33′ : 79° 29′), Asola (20° 14′ : 79° 46′) and Dewalgaon (20° 23′ : 79° 59′). The total reserves in all these deposits are estimated at 22 million tons.

*Ratnagiri district* Iron ore occurs in the enriched upper portions of banded ferruginous rocks forming part of the Dharwarian system in a series of exposures near Kankauli (16° 16′: 73° 45′), east of Vagda (16° 14′: 73° 45′), east-north-east of Kasal, south-south-west of Kunda (16° 9′: 73° 46′), near Katta (16° 5′ : 73° 40′), and at Redi (15° 45′ : 73° 44′). The

deposit at Redi is the largest, being about a mile long and 500 yd. or more wide, rising to a height of 220 ft. Its surface shows somewhat lateritic material lying above hematite of good quality.

In the former Saurashtra region of the State lateritic iron ore of good quality (44–67% iron) occurs in Navanagar in fairly large quantities, particularly around Nandana (22° 8′ : 69° 20′), Ran (22° 10′ : 69° 20′), Mewasa (22° 13′ : 69° 21′), Habardi (22° 13′ : 69° 25′), Virpur (22° 15′ : 69° 21′) and Asota Mota (22° 16′ : 69° 25′). Deposits of iron ore also occur in Porbandar, Junagadh and Bhavanagar. These deposits are, however, not of much economic importance at present (Roy, 1953, 155).

*Goa*—Several deposits are known to occur at Bicholim (15° 30′: 73° 55′), Sirigao and Kosti. The ore at Bicholim is associated with banded ferruginous rocks forming part of the Dharwarian system. The deposit consists of lateritic ore at the surface over hard and somewhat porous hematite containing small quantities of magnetite. Bicholim ore contains 60–62% iron. The ore at Sirigao is similar to that of Bicholim and contains 57–58% iron. The Kosti deposit is said to be derived from a ferruginous green schist and consists of magnetite with some hematite and limonite. All the deposits are being worked for export. The reserves at Bicholim, Sirigao and Kosti are reported to be of the order of 250 million, 30 million, and 7 million tons respectively (Krishnan, *Bull. geol. Surv. India, Ser. A.*, No. 9, 1954, 138).

Himachal Pradesh

*Mandi*—In Mandi, appreciable quantities of iron ore occur in a band nearly 11 miles long. The ore body consists of banded magnetite schists and micaceous hematite schists alternating with quartzite and contains 43–48% iron. The ore is friable and can be easily crushed and concentrated electromagnetically to yield a concentrate of 63.7% iron content. The reserves up to a depth of 300 ft. are estimated at 60 million tons. As the deposits are located in a difficultly accessible region, the ore is not being exploited at present (Roy & Mukherjee, *Quart. J. geol. Soc. India*, 1939, **11**, 49).

Jammu & Kashmir

Deposits of iron ore have been recorded at Gangani (34° 8′: 76° 8′), Ladda, Matah (33° 8′: 74° 44′), and Khandli (33° 26′ : 74° 28′). The deposits are not of much significance.

Madhya Pradesh

Extensive deposits of iron ore of excellent quality occur in Bastar, Drug, Chanda and Jabalpur districts.

*Bastar district*—Iron ore occurs in Bailadila mountains and at Rowghat. The ore in Bailadila mountains is found in pre-Cambrian sedimentary formations, called the Bailadila Iron Ore Series, which resembles the Iron Ore Series of Bihar and Orissa. It is mostly hematite; a few small deposits contain magnetite. So far, 14 deposits have been located, 5 on the western side and 9 on the eastern side of the Bailadila range; 8 of these are large and important. In general, the ore near the surface consists of massive, compact, almost pure hematite (over 68% iron); large quantities of high grade debris or floats are found on the hillsides surrounding the major deposits. The reserves in the deposits of this region have been conservatively estimated at 610 million tons up to a depth of 200 ft., but the actual reserves may be 5 or 6 times this figure (Crookshank, *Trans. Min. geol. Inst. India*, 1938, **34,** 253; Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 147).

At Rowghat in Narainpur tehsil there are 6 major deposits (between north latitudes 19° 46′ and 19° 55′, and east longitudes 80° 6′ and 81° 12′) of hematite in precipitous hills, 1,500 ft. above the general level of the surrounding country. The total reserves up to a depth of 150 ft. have been conservatively estimated at 740 million tons.

Near Parrekaro (20° 23′: 81° 4′) deposits of massive hematite and of micaceous hematite have recently been located in the Aridungri hill. The workable reserves up to a depth of 200 ft. have been estimated at 6 million tons of massive ore and 20 million tons of micaceous ore. Recently 10 deposits of high grade iron ore with an estimated reserve of over 12 million tons have been located in Hahalaodi (20° 3′ : 80° 50′) [Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 150; Chatterji, *Rec. geol. Surv. India*, 1954, **85** (pt 1), 65].

*Drug district*—High grade iron ores, extending about 20 miles, occur on the Dhalli and Rajhara hills (20° 34′: 81° 4′). The ore is derived from banded hematite-quartzites. The exposures show abundant boulders and blocks of ore strewn on the surface. The ore bodies are lenticular in shape. The ore is massive, compact and hard hematite with small quantities of magnetite in some places, and occupies the tops of ridges. Hydrated oxides and lateritic products are also found occasionally. The main ore bodies are found in Rajhara pahar (20°34′ : 81°5′),

west of Rajhara pahar, south of Jharandalli (20°34′ : 81°4′), Kondekasa (20°35′ : 81°2′), and the ridge south-west of Kondekasa. The total reserves in this area have recently been estimated at 150 million tons of high grade ore of over 60% iron; according to earlier estimates the reserves were about 114 million tons [Chatterji, *Rec. geol. Surv. India*, 1953, **84** (pt 1), 77].

*Jabalpur district*—Iron ore occurs in the north-eastern parts of the district. The principal ores are micaceous and siliceous hematite, part of which has been converted into laterite. The important deposits are located near Agaria hill (23°23′ : 80°11′), Jauli (23°23′ : 80°16′), Silondi (23°30′ : 80°8′), Gosalpur (23°24′ : 80°5′), Ghogra (23°29′ : 80°14′), Saroli (23°24′ : 80°13′), and Kanhwara hills (23°55′ : 80°28′). The bed of laterite ore found on the top of Agaria hill is 7–10 ft. thick and contains specular hematite in the form of pebbles and fragments. The quantity of laterite in this hill has been estimated at 14 million tons, though the reserves of richer laterite, containing 49–59% iron might be only 0.75 million tons.

Large deposits of lateritic iron ore consisting mainly of pisolitic hematite, occur in and around Kanhwara hills, covering an area of over 2½ sq. miles. The total quantity available in this area has been estimated at 49 million tons.

The ores in Jabalpur district are of rather low grade (45–60% iron). Most of them are friable and mixed with shaly or siliceous impurities, but they can be improved by beneficiation. The total reserves in the district are estimated at 100 million tons (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 157).

Fairly extensive cappings of laterite rich in iron are found in the districts of Guna, Shivpuri, Shahjapur, Bhilsa, Ujjain and Mandasor. Occurrences of iron ore have also been reported from Par hill (26°2′ : 78°4′), Mangor (26°5′ : 78°4′), Santao (26°6′ : 78°9′), Ratangarh (24°48′ : 75°7′), Jat (24°51′ : 74°57′), Pardha (24°32′ : 75°10′), Bain (22°25′ : 76°43′), Sendrani (22°28′ : 76°38′), Bhaurikhera (22°22′ : 76°25′) and a few other localities. The deposits are of little importance at present (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 139).

### Madras

Iron ore deposits of some importance occur in Salem and Tiruchirapalli districts. Several occurrences in other districts are known, but they are not considered important at present.

*Salem and Tiruchirapalli districts*—Extensive deposits of magnetite-quartz rocks occur in a series of ridges and hillocks in these districts. The major deposits are Kanjamalai, Godumalai, Perumamalai, Thirthamalai, Kollaimalai, Pachaimalai and Chitteri. Deposits are also found in several hills in Attur valley and the area between Namakkal and Rasipur. Of these deposits, the Kanjamalai, a hill 5 miles west-south-west of Salem town, is the most important, the average iron content being 35–40%.

The ore consists of banded magnetite-quartzite, originally deposited as banded ferruginous sediments, similar to those of Bihar and Madhya Pradesh. Subsequent regional metamorphism has converted the ore into magnetite-quartzites. Sometimes the ore contains small quantities of amphiboles. The reserves of workable ores in these two districts have been estimated at 304.5 million tons up to a depth of 100 ft. (Krishnan & Aiyengar, *Bull. geol. Surv. India, Ser. A*., No. 8, 1954, 53).

### Mysore

The iron ore deposits of Mysore belong mainly to the sedimentary group, associated with banded hematite-quartzites of Dharwarian age, which stand out as prominent ridges; titaniferous ore deposits of magmatic origin associated with ultramafic rocks are also found in small quantities.

*Bellary district*—In Sandur area, banded hematite-quartzites, similar to those of Singhbhum and Orissa, occur in two groups of ore ridges, one on the eastern side and the other on the western side of the Sandur fold belt. The banded hematite-quartzites have been altered at and near the surface to rich masses of hard, compact, steel grey hematite. Laminated, shaly and soft ores are also found in this area; the soft ores sometimes yield red oxide, suitable for use in paints.

The deposits (iron content, 63–68%) occur mainly on the following ridges: Donimalai (25.6), Devadari (15.0), Kumaraswami-Kammadhevuru (25.4), Kanavehalli (0.5), Ramandrug (30.3), and Timmappanagudi (32.8); the figures in parenthesis give the estimated reserves in million tons, the total amounting to 129.6 million tons.

*Dharwar district*—There are deposits of banded hematite-quartzite which form part of the Dharwarian sequence; several bands of enriched hematite also occur in a few places, notably at Kusalpur and Tegur. The ore at Kusalpur (15°10′ : 75°46′) is siliceous ($SiO_2$, 10–15%); the iron content of the ore is 45–60% and the phosphorus content, up to 0.7%.

The total reserves of good ore in this area up to a depth of 30–40 ft. have been estimated at 7.5 million tons. The Tegur area (15°33′ : 74°51′) is estimated to contain 1 million tons of ore of 43–51% iron content (Roy, 1951, 77 ; Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 137).

*Other districts*—As in Bellary district, the banded hematite-quartzites in other districts of the State have given rise to large ore bodies of hard compact hematite at and near the surface. Sometimes, in these deposits, the surface contains a mantle of lateritic ore. The thickness of the enriched ore is reported to vary between 50 and 200 ft. Associated with some of the banded ferruginous rocks are schists and shales which have also been replaced to some extent by iron oxide, making them fairly rich in iron : these ores were once worked and iron produced in indigenous furnaces.

Deposits of enriched iron ore (50–65% iron) occur at the following places: *Chikmagalur district*—Kemmangundi (436), Kalhatti (26), Kudremukh—magnetite-quartzite (84); *Chitaldrug district*—Hiriyur (276) ; Holalkere—Kanekalmonti : *Hassan district*—Dodgudda : *Shimoga district*—Sidharhalli (1), Joldhal, Gangur, Bhadigund, Shankargudda (25), Chattanhalli, Agumbe, Kodashadri, Ambaragudda : and *Tumkur district*—Karekurchi ; figures in parenthesis give the estimated reserves in million tons. The total reserves in these deposits are estimated at 848 million tons, consisting of 764 million tons of hematite ores and 84 million tons of magnetite ores.

Titaniferous magnetite iron ores, associated with ultramafic rocks containing chromite, occur in several places particularly in southern Mysore. These deposits are rich in iron (55–61%) and contain up to 12% titanium and occasionally, vanadium. The chief deposits occur notably at Ubrani, Devanarsipur, Kunigal and a few places in the Nuggihalli schist belt in Tumkur district. Potential titaniferous magnetites in Mysore State have been estimated at 131 million tons. The total reserves of different types of ores in the State are estimated at 1,119 million tons. While calculating the reserves in most cases the depth of the deposits has been assumed to be 50 ft. ; however, it is likely that the ores extend to a depth of 100 ft. or more. Thus the potential reserves in the State may be much more than the present estimates.

### Punjab

Several deposits of minor importance occur in the State. In Kangra district, magnetite occurs near Dharman (32°4′ : 76°49′). In Sirmur district, lenses of magnetite with some hematite occur near Kaneri (30°47′ : 77°21′) and Lana Chahta (30°48′ : 77°22′), 15 miles east of Nahan town.

In Patiala district, a few bands of magnetite (57.4% iron) with some hematite occur on a low ridge which runs from Chhapri (27°56′ : 76°7′) to Jaunpur, a distance of 2.5 miles. The reserves of iron ore in this region are estimated at over 2 million tons [*Indian Min. J.*, 1957, **5**(2), 19].

In Narnaul district there are some minor hematite and magnetite deposits, but details of their occurrences are lacking (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 107).

### Rajasthan

In Alwar district iron ore occurs in Aravalli limestones, Alwar quartzites and hornstone breccia near Kushalgarh (27°26′ : 76°29′), Tehla (27°14′ : 76°28′) and Rajgarh (27°14′ : 76°41′).

In Bundi, limonite and hematite form veins in limestones of the Aravalli system between Bundi and Deoli and also near Loharpura (25°28′ : 75°40′).

In Jaipur division, between Raipur (27°44′ : 76°1′) and Jaitpura (27°39′ : 76°0′), bands of micaceous hematite schists and irregular masses of hematite occur in the limestones of Ajabgarh series. The largest deposit forms a small ridge about a mile long near Neemla (27°5′ : 76°19′). A picked sample analysed to 66.7% iron.

In Udaipur division, rich pockets of iron ore consisting of limonite and hematite occur between Raipuria (25°5′ : 74°36′) and Gangrar (25°3′ : 74°37′). Hematite occurs as a prominent ridge at the base of the Aravallis near Thana (24°13′ : 73°52′) (Heron, *Trans. Min. geol. Inst. India*, 1935, **29**, 356).

In Jaisalmer division north-east of Jaisalmer town, the presence of extensive deposits of rich iron ore, 1,000–1,500 ft. below the surface has been indicated.

### Uttar Pradesh

Iron ore occurs in the districts of Garhwal, Naini Tal and Almora. In Garhwal district numerous beds of micaceous hematite exist near Nagpur Pargana (30°31′ : 79°13′). Some of these are 50 ft. or more in thickness.

Red and brown hematite beds have been found at Simalkhet (29°47′ : 79°27′) and in the Ponaar valley (29°31′ : 79°55′) in Almora district. The deposits are of no economic importance.

In Naini Tal district, hematite deposits occur in

several places, particularly in Ramgarh, Khairna Kaladhungi and Dechauri. A few million tons of ore are reported to exist in this area (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 181).

### West Bengal

*Burdwan district* – Iron ore occurs in the Raniganj coalfield in the form of thin bands, lenticular masses, and strings of nodules of clay ironstone (limonite) in the Ironstone Shales which form the middle division of the Damuda series (lower Gondwana). The ironstone shale formation is exposed over 33 miles east to west and has an average thickness of 1,200 ft. The ores are high in phosphorus (P, 0.31%) and have an average iron content of 39%. They were formerly used by the *Bengal Iron Co.* at Kulti, but with the discovery of rich hematite ores in Singhbhum district of Bihar, the use of these ores for smelting purposes was discontinued. The total area covered by this formation including that with a thin cover of alluvium between Barakar and Ajai rivers is about 44 sq. miles. The total reserves are estimated at over 500 million tons.

Small deposits of hematitic clay-ironstone, ferruginous laterite, and magnetite associated with metamorphic quartzite occur east and south of the Raniganj coalfield. They are poor in iron and not of much economic importance.

In Birbhum district, veins of limonite occur in the sandstone of the Damuda and Mahadeva series belonging to the Gondwana system. Layers of pisolitic iron ore and pockets and thin beds of limonite and hematite are also found in laterite amidst flows of the Rajmahal Trap (of Jurassic age). These deposits are small and patchy (Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 111).

### Reserves

The estimated reserves of high grade iron ore containing 60% or more of iron in the different States are given in Tables 5 & 6. The estimates have been worked out by the Geological Survey of India as a result of surface examination. In some cases, detailed prospecting work has been done by commercial firms and the reserves for individual deposits have been found to be more than twice the amount estimated by the Geological Survey. The reserves of Bihar and Orissa were placed by Dr. Percival of the *Tata Iron & Steel Co. Ltd.*, at 8,000 million tons as against 2,700 million tons estimated by the Geological Survey. It would thus appear that in actual working, the figures given under 'probable' in Table 6 would be realised and, in some cases, even exceeded if lower grade ores (55% and below) are also taken into account.

**TABLE 5—ESTIMATED RESERVES OF HIGH GRADE IRON ORES***

(million tons)

| | Hematite | Magnetite |
|---|---|---|
| *Andhra* | | |
| Kurnool, Adilabad, Karimnagar, Nizamabad & Warangal | 41 | |
| Guntur & Nellore | . | 389 |
| *Bihar & Orissa* | .. | 5 |
| Singhbhum | 1,047 | |
| Keonjhar | 988 | .. |
| Bonai | 648 | |
| Mayurbhanj | 60 | . |
| *Bombay* | | |
| Ratnagiri | 20 | . |
| Chanda | 22 | .. |
| *Himachal Pradesh* | .. | 60 |
| *Kashmir* | 5 | . |
| *Madhya Pradesh* | .. | . |
| Drug (Dhalli-Rajhara) | 114 | . |
| Bastar (Bailadila) | 610 | . |
| Bastar (Rowghat) | 740 | .. |
| Jabalpur | 100 | .. |
| *Madras* | | |
| Salem-Tiruchirapalli | .. | 305 |
| *Mysore* | .. | 215 |
| Bellary (Sandur) | 130 | . |
| Dharwar | 10 | .. |
| Other districts including Chikmagalur, Chitaldrug, Shimoga & Tumkur | 764 | |
| *Punjab* | | |
| *Rajasthan* | | |
| *Uttar Pradesh* | 10 | .. |
| Total | 5,316 | 974 |
| Grand Total‡ | 6,790 | |

* *Mineral Production in India*, Indian Bureau of Mines, 1956, 70.

‡ Including 500 million tons of limonitic and spathic ores occurring in West Bengal.

TABLE 6—ESTIMATED AND PROBABLE RESERVES OF HIGH GRADE IRON ORES*
(million tons)

| | Geol. Surv estimates | Probable reserves |
|---|---|---|
| HEMATITE: | | |
| *Andhra* | 41 | |
| *Bihar & Orissa* | 2,743 | 8,000 |
| *Bombay* | 42 | 300 |
| *Madhya Pradesh* | 1,564 | 7,000 |
| *Mysore* | 904 | 2,300 |
| *Kashmir* | 5 | .. |
| *Punjab* | 2 | 30 |
| *Rajasthan* | 5 | |
| *Uttar Pradesh* | 10 | |
| Total | 5,316 | 17,630 |
| MAGNETITE: | | |
| *Andhra* | 389 | 389 |
| *Bihar & Orissa* | 5 | .. |
| *Himachal Pradesh* | 60 | 60 |
| *Madras* | 305 | 1,000 |
| *Mysore* | 215 | 500 |
| Total | 974 | 1,949 |
| LIMONITIC and SPATHIC ORES: | | |
| *Bengal* | 500 | 2,000 |
| Grand Total | 6,790 | 21,579 |

* *Mineral Production in India*, Indian Bureau of Mines, 1956, 70; Krishnan, *Bull. geol. Surv. India, Ser. A*, No. 9, 1954, 182.

### MINING AND BENEFICIATION

The mining of iron ore in India is done by open cast workings. Simple hand methods are mainly employed, but sometimes blasting holes are drilled by mechanical methods. At Noamundi, steam shovels are used for loading. As the ore occurs in hills, the mined ore is conveyed to railway tracks on the plains either by aerial ropeways or by inclines.

At present high grade iron ores with an average iron content of over 60% are used for iron and steel manufacture by the major iron and steel companies in Bihar and Bengal, and ores of 55-60% iron content are smelted in the *Mysore Iron & Steel Works*, Bhadravati. The phosphorus content of Indian iron ores is rarely high: the alumina content varies between 4 and 5%.

Elsewhere, iron ores are often concentrated to reduce freight, remove undesirable impurities and increase the iron content of the ores, thus increasing the blast furnace output by reducing the amount of slag to be fluxed and removed. Some constituents, such as sulphur and carbon dioxide, may be removed by heating; interstitial matter or gangue may be separated by hand picking, simple screening, or by plain washing. In addition, crushing and separation by jigging or by electromagnet, as in the case of magnetic ores, may be adopted.

As only high grade hematite containing very little magnetite is being mined in India at present, the treatments necessary to obtain ore of uniform quality for blast furnace operation consist of breaking and crushing the larger lumps in hand or gyratory crushers at the loading points and subsequent screening and/or washing to remove the fines. The removal of fines which are usually richer in alumina and silica than the lumps, helps in concentrating the ore. It is also necessary to blend the different grades of ores to give a uniform burden in the blast furnace. This is now done by storing the various grades of ore in separate bins and drawing off skip loads in fixed proportions. Washing the ores by water in rotary washers is being done at Noamundi since 1953.

Recent investigations at the *National Metallurgical Laboratory*, Jamshedpur, have shown that iron ore fines, obtained during the mining and crushing of ore, can be sintered into sizable lumps after mixing with coke breeze, blast furnace flue dust, finely crushed limestone, etc. Sintered lumps are suitable for use in the manufacture of pig iron (*Res. & Ind.*, 1958, **3**, 160).

TABLE 7—PRODUCTION OF IRON ORE IN INDIA
(Qty in tons and val. in thousand Rs.)

| | Qty | Val. |
|---|---|---|
| 1934-38 (av.) | 2,498,489 | 19,857 |
| 1939-43 (av.) | 3,067,696 | 27,595 |
| 1944-48 (av.) | 2,363,710 | 36,439 |
| 1949 | 2,808,522 | 12,666 |
| 1950 | 2,971,276 | 15,369 |
| 1951 | 3,656,661 | 20,945 |
| 1952 | 3,925,511 | 26,833 |
| 1953 | 3,854,850 | 28,091 |
| 1954 | 4,308,273 | 28,936 |
| 1955 | 4,677,538 | 32,315 |
| 1956 | 4,857,914 | 39,503 |
| 1957† | 5,066,000 | 43,346 |

† Provisional

### Manufacture of Iron & Steel

For the manufacture of pig iron, iron ore, fuel (normally metallurgical coke) and flux (limestone) in the required proportions are fed into the blast furnace at the top. Hot air is blown into the furnace through a ring of tuyeres near the base. Often, small additions of manganese ore are made to give the desired manganese content in the pig iron.

The combustion of coke with the hot blast inside the furnace gives temperatures of *c.* 2,700°F. The oxygen of the ore combines with the carbon of the coke allowing the released iron to melt and work its way down into the hearth at the bottom of the furnace. Silica, alumina and certain other impurities of the ore and the coke combine with lime and magnesia of the flux to form a fluid slag. This slag, being lighter than iron, floats on the surface and is drawn off at intervals. The heavier liquid iron is tapped out and either treated immediately in a furnace to produce steel or cast in a pig casting machine or in a sand bed into bars for use in foundries. Pig iron is also manufactured in electric smelting furnaces.

For steel manufacture, pig iron is refined in a Bessemer converter or an open-hearth furnace or in an electric arc furnace. In the Bessemer converter, the refining is done by blowing air through the liquid pig iron, which oxidizes the impurities. In the open-hearth furnace the heat required is produced by burning gases or liquid fuel with preheated air. Oxidation of the impurities present in the molten pig iron is effected partly by the oxidizing flame and partly by the addition of rich iron ore. In the commonly used basic open-hearth furnace, lime is added to combine with phosphorus and silica to form a slag. In the electric arc furnace solid or molten pig iron is refined by blowing in air or oxygen, or by mixing the pig iron with partly reduced sponge iron. The refined steel is finished at the time of tapping by small additions of ferro-alloys and carbonaceous material. The steel is tapped into ladles and teemed into ingot moulds.

Pig iron is at present made by the *Tata Iron & Steel Co. Ltd.*, Jamshedpur, the *Indian Iron & Steel Co. Ltd.*, Burnpur and Kulti, and the *Mysore Iron & Steel Works*, Bhadravati. Except the Kulti works, all the other works manufacture steel. Small quantities of steel are also produced by about a dozen manufacturers. Recently three State-owned, integrated iron and steel plants have been set up at Rourkela, Bhilai and Durgapur. By the end of 1960 the total annual steel production capacity is expected to reach 6 million tons of ingot steel; of this, 3 million tons are to be produced by expanding the existing units, while the other 3 million tons are to be produced by the new steel plants.

**TABLE 8—STATE-WISE PRODUCTION OF IRON ORE IN 1955-1956***

(Qty in tons and val. in thousand Rs.)

| | 1955 | | 1956 | |
|---|---|---|---|---|
| | Qty | Val. | Qty | Val. |
| Andhra Pradesh | 386,338 | 3,134 | 402,382 | 5,417 |
| Bihar | 1,919,974 | 12,982 | 1,847,538 | 12,599 |
| Bombay | 49,623 | 499 | 127,047 | 1,324 |
| Madhya Pradesh | 6,391 | 24 | 32,719 | 260 |
| Mysore | 363,524 | 2,931 | 540,671 | 2,015 |
| Orissa | 1,882,117 | 12,327 | 1,770,378 | 16,818 |
| Punjab | 24,283 | 108 | 14,905 | 118 |
| Rajasthan | 45,288 | 310 | 122,274 | 952 |
| Total | 4,677,538 | 32,315 | 4,857,914 | 39,503 |

* *Mineral Production in India*, Indian Bureau of Mines, 1956, 71.

**TABLE 9—GRADE-WISE PRODUCTION OF IRON ORE IN 1956***

(tons)

| | % iron in ore | | | | |
|---|---|---|---|---|---|
| | Below 55 | Between 55 & 60 | Between 60 & 62 | Between 62 & 64 | Above 64 |
| Andhra Pradesh | 8,044 | 83,065 | 21,919 | 203,369 | 85,985 |
| Bihar | 1,015 | 1,336,027 | 375,951 | 131,267 | 3,278 |
| Bombay | 12,000 | 103,900 | .. | .. | 11,147 |
| Madhya Pradesh | .. | .. | .. | 3,004 | 29,715 |
| Mysore | 179,859 | 11,847 | .. | 9,187 | 339,778 |
| Orissa | 303,270 | 886,806 | 92,974 | 157,560 | 329,768 |
| Punjab | .. | .. | .. | 14,905 | .. |
| Rajasthan | .. | .. | 25,029 | 39,802 | 57,443 |
| Total | 504,188 | 2,421,645 | 515,873 | 559,094 | 857,114 |
| % of total production of all grades | 10.37 | 49.85 | 10.62 | 11.51 | 17.65 |

* *Mineral Production in India*, Indian Bureau of Mines, 1956, 72.

TABLE 10—EXPORTS OF IRON ORE FROM INDIA

(Qty in tons and val. in thousand Rs.)

| | Qty | Val. |
|---|---|---|
| 1935-36-1939-40 (av.) | 110,248 | 814 |
| 1950-51 | 84,513 | 2,221 |
| 1951-52 | 280,036 | 9,996 |
| 1952-53 | 810,025 | 37,047 |
| 1953-54 | 1,261,977 | 57,867 |
| 1954-55 | 1,008,878 | 42,113 |
| 1955-56 | 1,362,776 | 62,738 |
| 1956-57 | 1,792,606 | 93,129 |

TABLE 11—PRICE (F.O.B.) OF IRON ORE*

(Rs. per ton)

| Grade (% iron) | Port | 1956 | 1957† |
|---|---|---|---|
| 60-62 | Calcutta | 48.00-51.50 | 43.00-53.00 |
| 62-65 | Calcutta | 47.00-52.50 | 45.00-56.00 |
| 65-67 | Visakhapatnam | 45.00-51.50 | 44.00-50.00 |
| 67 & above | Madra | 50.00-56.10 | 45.00-60.00 |

* Information from Indian Bureau of Mines.
† Provisional.

PRODUCTION & TRADE

The production of iron ore in 1956 was 4.86 million tons; by 1960-61 the production of iron ore is expected to increase to 12.5 million tons. Nearly 75% of the total output is smelted for pig iron and the rest is exported. Tables 7 and 8 give the production of iron ore in India. Table 9 gives grade-wise production of iron ore in 1956 in different States. Table 10 gives the exports of iron ore from India. There was no export during 1940/41-1948/49. Japan is the principal importer of Indian iron ore.

*Prices*—Table 11 gives the prices of various grades of iron ores, f.o.b. Calcutta, Visakhapatnam and Madras in 1956 and 1957.

**Iron-wood Tree** — *see* **Memecylon**

**Iron-wood Tree of Assam** — *see* **Mesua**

**Iron-wood Tree of Burma** — *see* **Xylia**

**Irul** — *see* **Xylia**

**ISACHNE** R. Br. (*Gramineae*)

A small genus of perennial grasses distributed throughout the tropical and sub-tropical regions of the world. About 20 species are recorded in India.

**I. albens** Trin.

D.E.P., III, 436; Fl. Br. Ind., VII, 22.

An erect, branched grass, 1-4 ft. high with flat, linear to linear-lanceolate leaves, found in the temperate and sub-tropical Himalayas, from Simla eastwards to Sikkim up to 9,000 ft. and Assam up to 4,500 ft. It is occasionally found in the plains. A variety, *I. albens* var. *hirsuta* Hook. f., found in Cachar (Assam), has broad leaves. The grass is readily eaten by cattle. Analysis of the grass gave the following average values (dry basis): protein, 8.50; fat, 0.76; carbohydrates, 44.56; fibre, 33.32; and ash, 12.85%. The tender tops are said to be eaten with rice in Java (Burkill, II, 1252; Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 207).

**I. globosa** (Thunb.) Kuntze syn. *I. australis* R. Br.

D.E.P., IIII, 423, 433; Fl. Br. Ind., VII, 24.

BOMBAY—*Dauria, douria*.

A short, slender, sub-gregarious, tufted grass, up to 2 ft. high, found in wet and marshy places, from Punjab eastwards to Assam and in Gujarat, Deccan, western ghats, west coast and Nilgiri and Pulney hills. It is a common weed in cultivated fields. The grass is eaten by horses and cattle. Analysis of the grass gave the following average values (dry basis): protein, 10.52; fat, 1.76; carbohydrates, 40.00; fibre, 31.99; and ash, 15.73%. The grass is ploughed in as green manure. Tender tops are reported to be eaten in Java like those of *I. albens* (Duthie, 1888, 3; Blatter & McCann, 189; Walandouw, loc. cit.; Burkill, II, 1253).

**I. miliacea** Roth

Fl. Br. Ind., VII, 25.

A low, slender, tufted grass, 6-10 in. high, with prostrate, creeping, branched base and small, flat, lanceolate or ovate-lanceolate leaves. It is found in Sikkim terai, Bihar, West Bengal, Assam, Andhra, Madhya Pradesh, west coast from Konkan to North Kanara, western ghats and Nicobar Islands, usually in wet and marshy places. It is a good fodder grass readily eaten by cattle and horses. Analysis of the grass gave the following average values (dry basis): protein, 10.45; fat, 1.49; carbohydrates, 41.79; fibre, 28.97; and ash, 17.30% (Blatter & McCann, 189; Rhind, 44; Walandouw, loc. cit.).

FIG. 142. ISACHNE GLOBOSA

*I. dispar* Trin. is a low grass, 2–6 in. high, with ovate-cordate to lanceolate-acuminate leaves. It occurs in the upper Gangetic plain, Nepal, Sikkim terai, Goalpara in Assam, Orissa, Mt. Abu and Madras, ascending to 6,000 ft. The grass is common in wet and swampy situations and is a troublesome weed in rice fields. It is eaten by cattle and horses (Fl. Madras, 1797).

*I. rigida* Nees = *I. pangerangensis* Zoll. & Moritzi var. *rhingnon* (Steud.) Henr., a short grass, 6–16 in. high, with ovate to ovate-lanceolate leaves, is found in Nicobar Islands. It is considered to be a fodder grass, but the yield of foliage is small (Burkill, II, 1253).

**ISATIS** Linn. (*Cruciferae*)

D.E.P., IV, 524; C.P., 663; Fl. Br. Ind., I, 163.

A genus of erect, branching annuals or biennials, distributed in central Europe, Mediterranean region and central and western Asia. One species, *I. tinctoria* Linn. (DYER'S WOAD), a native of western Tibet and Afghanistan, was being cultivated in central and southern Europe for its dye before the advent of synthetic indigo. It is reported to be grown in Indian gardens.

*I. tinctoria* is a herbaceous biennial, 1½–3 ft. high, with entire or coarsely toothed radical leaves and small yellow flowers borne on panicled racemes. A dark clay-like preparation, Woad, obtained from the leaves, was once used as a dyestuff in Britain and other European countries. Woad was prepared, by crushing the fresh leaves into a pulp, kneading into balls and drying them in the sun. The balls were later pulverised, water added and the mass fermented with frequent turning. The fermented product was dried and packed for use by the dyer (Hutchinson & Melville, 235; Perkin & Everest, 476; Kierstead, 29; Barclay, *Discovery*, 1952, **13**, 243; Wallace, *Agriculture, Lond.*, 1954–55, **61**, 501; Thorpe, XI, 969).

The richness of the shade imparted by the dye to the fabric depends on the quality and quantity of woad used and the frequency with which the fabric is immersed in the dye bath. A fresh bath gives a deep black shade; as the solution weakens, lighter shades, ranging from dark blue to light green, are obtained. In combination with other natural dyes, woad gives a variety of shades. The colouring principle of the leaves is a glucoside, indican ($C_{14}H_{17}O_6N.3H_2O$; m.p., 57°), which is also present in *Indigofera* (q.v.). The plant is considered medicinal and used for ulcers and other ailments (Hutchinson & Melville, 235; McIlroy, 107; Schery, 241).

The roots of the plant contain a glycoside and the enzyme myrosin. The seeds contain 3-butenyl isothiocyanate. They also yield a fatty oil (31.3%) containing: oleic, 27; linoleic, 19; linolenic, 24; and erucic acid, 21% (Wehmer, I, 397; Kjaer *et al.*, *Acta chem. scand.*, 1953, **7**, 1279; Hilditch, 1956, 224).

**ISCHAEMUM** Linn. (*Gramineae*)

A large genus of annual or perennial grasses distributed throughout the tropical, sub-tropical and warm temperate regions of the world. Some species have been transferred to *Eulaliopsis* and *Sehima* (q.v.). About 30 species occur in India.

**I. aristatum** Linn. syn. *I. ciliare* Retz.

D.E.P., IV, 530; III, 423; Fl. Br. Ind., VII, 126, 133; Blatter & McCann, Pl. 6.

HINDI—*Kander*; TEL.—*Erruthola gaddi*; KAN.—*Mobbu ganjalu garikai hullu*; MAL.—*Chenkodi padappan pullu, pandam kuththi.*

MADHYA PRADESH—*Bara toriya-gadi, duikani ronda,*

*gondi, guhera, paba, piyana-koru-gadi, suhaga ;* Bombay—*Bangadi, bara, bherda, kanden, putena.*

A tufted, erect or decumbent, stout or slender, perennial grass, 1–4 ft. high, with linear leaves, found in wet and marshy places almost throughout India, up to 8,000 ft. It is eaten by cattle. Analysis of the grass from Madras gave the following values (air-dry material): moisture, 5.36 ; protein, 4.59 ; fat, 1.48 ; fibre, 41.49 ; carbohydrates, 42.11 ; and ash, 5.00% ; carotene content of green grass (moisture, 25.0%) from Bombay, 1.05 mg./100 g. It is reported from Trinidad that the milk from cows grazing on this grass possesses an undesirable odour, which is directly related to the quantity of grass consumed (*Mem. Dep. Agric. Madras*, No. 36, 1954, 612 ; Bharucha & Shankarnarayan, *Sci. & Cult.*, 1957–58, **23**, 311 ; Howes, *Trop. Agriculture, Trin.*, 1953, **30**, 224).

I. **muticum** Linn.

Fl. Br. Ind., VII, 132.

A low, rather coarse, extensively creeping, perennial grass, up to 2 ft. high, with a stout, vigorous rootstock and ovate to lanceolate leaves, found in Madhya Pradesh, South Kanara and Kerala, usually in marshes and coastal sands. It is gregarious on moist banks of streams and in paddy fields. It is considered to be a good fodder grass. Analysis of the grass (from Malaya) gave the following values: moisture, 74.0 ; protein, 2.4 ; fat, 0.4 ; carbohydrates, 14.9 ; fibre, 6.4 ; ash, 1.9 ; calcium (CaO), 0.05 ; and phosphorus ($P_2O_5$), 0.03% ; *digestible nutrients :* protein, 1.3 ; fat, 0.2 ; carbohydrates, 9.2 ; and fibre, 3.8% ; starch equivalent, 14.6 lb./100 lb. ; and nutritive ratio, 10.3. It is rich in vitamin C. The grass is a good sand binder and useful on banks and abandoned lands. The leaves are applied as poultice for headache (Rhind, 75 ; Teik, *Sci. Ser. Dep. Agric. Malaya*, No. 24, 1951, 20, 70, 78, 84 ; Burkill, II, 1253).

I. **pilosum** Hack.

D.E.P., IV, 531 ; III, 423 ; Fl. Br. Ind., VII, 130.

Tel.—*Kundara gaddi, urranki.*

Bombay—*Dungri-kunda, kanigyan hulla, nuth, pharari ;* Madhya Pradesh—*Kari, kunda.*

A tall, erect, perennial grass, 2–5 ft. high, with a stout stoloniferous rootstock, found commonly in black cotton soils, especially in Guntur and Ceded districts of Andhra State and in Madhya Pradesh. It is a troublesome weed in cultivated fields where it hinders agricultural operations. The grass is moderately relished by cattle. It is best fed before

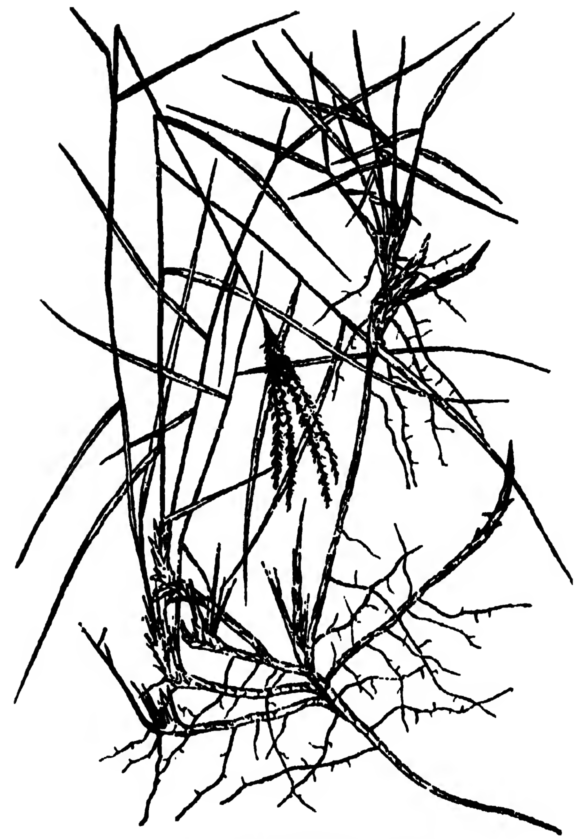


FIG. 143. ISCHAEMUM PILOSUM

flowering or just when flowers appear. It is also suitable for silage and rough hay. The yield of green fodder, in experimental trials at Ganeshkhind (Poona), is reported to be 6,000 lb./acre. Analysis of the grass (before flowering) gave the following values: moisture, 70.03 ; ether extr., 1.03 ; albuminoids, 2.17 ; carbohydrates, 14.56 ; woody fibre, 9.09 ; and ash, 3.12% (Burns *et al.*, *Bull. Dep. Agric. Bombay*, No. 78, 1916, 8 ; Tadulingam & Venkatanarayana, 327 ; Panikkar, *Sci. & Cult.*, 1949–50, **15**, 423).

I. **rugosum** Salisb.

D.E.P., IV, 531 ; III, 423 ; Fl. Br. Ind., VII, 127 ; Blatter & McCann, Pl. 7.

Beng.—*Moraro ;* Tam.—*Kadukken pillu.*

Punjab—*Mehat, munmuna ;* Uttar Pradesh—*Dhanua, marainda, maror, murchi ;* Rajasthan—*Jalgundya, toli ;* Santal—*Marudi ;* Madhya Pradesh—*Badaul, bhador, murdi, tori, tudi, jara ;* Bombay—*Bar, bardi, bher, karkel, lag ;* Assam—*Joya-jha.*

A tufted, erect, annual grass, 1–3 ft. high, with flat, linear-lanceolate, glabrous or sparsely hairy leaves and oblong grains, found throughout the

greater part of India up to an altitude of 6,000 ft., and in Andaman Islands. The grass is found in open and wet grasslands, marshy situations, shady areas and on black soils. It is a common weed in paddy fields (Bor, *Indian For. Rec., N.S., Bot.*, 1940, **2,** 147).

The grass is eaten by cattle and horses, and is considered to be a good fodder. Feeding trials show that it is comparable to common cultivated fodder plants in nutritive value. Analysis of the grass, at flowering stage, gave the following values (dry basis): crude protein, 7.13; ether extr., 2.50; crude fibre, 29.80; N-free extr., 50.50; ash, 10.07; calcium 0.38; and phosphorus, 0.31%; *digestibility co-efficients:* dry matter, 58; crude protein, 62; ether extr., 71; crude fibre, 63; and N-free extr., 59%; calcium and phosphorus balances are positive. Hay prepared from the grass at the flowering stage is not much relished by cattle. Analysis of the hay gave the following values (dry basis): crude protein, 6.63; ether extr., 2.18; crude fibre, 33.72; N-free extr., 47.84; ash, 9.63; calcium, 0.37; and phosphorus, 0.24%; *digestibility co-efficients:* dry matter, 52; crude protein, 42; ether extr., 55; crude fibre, 66; and N-free extr., 49%; digestible protein, 2.4; and starch equivalent, 26.7 lb./100 lb.; nitrogen and phosphorus balances are positive and calcium balance is negative. The grains are said to be used as food by the poor in some parts of Madhya Pradesh (Das & Mukherjee, *Indian J. vet. Sci.*, 1952, **22,** 239).

Besides the species described above, a few others find some use as fodder. *I. rangacharianum* Fischer (MAL.—*Chenkodi pullu*) is a creeping perennial grass found in Kerala. It is grazed by cattle, but is not considered to be a good fodder. *I. semisagittatum* Roxb. syn. *I. conjugatum* Roxb. (BOMBAY—*Ber, dalage, kari, saj-kadi*) is a slender, annual or perennial grass, 1–2 ft. high, found in West Bengal, Madhya Pradesh, west coast, western ghats and Deccan up to 4,000 ft. It is usually found in nurseries and bunds of paddy fields and is abundant on the crest of ghats in N. Kanara. The grass is reported to be a good fodder. *I. timorense* Kunth (KAN.—*Nilamunga hullu*) is a short, slender, straggling, perennial grass, about 1½ ft. high, found in Assam, western slopes of Nilgiris, north Coimbatore hills, western ghats and west coast in N. Kanara and Kerala. It is readily eaten by animals and is considered to be a useful fodder. Analysis of the grass from Indonesia gave the following values (dry basis): protein, 7.61; fat, 1.21; carbohydrates, 44.23; fibre, 32.51; and ash, 14.44% (Fl. Madras, 1722; Jacob, *Madras agric. J.*, 1942, **30,** 179; Tiwari, *Indian For.*, 1955, **81,** 107; Blatter & McCann, 16; Burkill, II, 1254; Walandouw, *J. sci. Res. Indonesia*, 1952, **1,** 201).

## ISEILEMA Anderss. (*Gramineae*)

A small genus of annual or perennial grasses found in the Indo-Malayan region and Australia. Four species are recorded in India.

### I. anthephoroides Hack.

Fl. Br. Ind., VII, 219; Blatter & McCann, Pl. 72.

HINDI—*Mushel*; TEL.—*Chengalli gaddi.*

MADHYA PRADESH—*Bhuri, gadru, garar musyal, masuri, musar*; BOMBAY—*Fudali bhathi, jejjegyan hullu, tambad gota.*

An erect, densely tufted, branching annual or perennial grass, 1–1½ ft. high, with short, sub-obtuse leaves occurring in the upper Gangetic plain, Madhya Pradesh, Orissa, coastal districts from Ganjam to Nellore, Cuddapah and Bellary districts, Deccan and western ghats. It is common in forest blanks and grazing grounds. It is frequently gregarious and is a good fodder grass relished by cattle in the flowering stage. Analysis of the grass gave the following values: moisture, 7.23; ash, 11.08; protein, 4.26; fat, 1.99; fibre, 32.17; and carbohydrates, 43.27% (Tiwari, *Indian For.*, 1955, **81,** 107; *Mem. Dep. Agric. Madras*, No. 36, 1954, 608; Burns *et al.*, *Bull. Dep. Agric. Bombay*, No. 78, 1916, 11; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 14).

### I. laxum Hack.

D.E.P. IV, 524; III, 423; Fl. Br. Ind., VII, 218.

HINDI—*Mushan, mushel*; TEL.—*Erra chengali gaddi*; TAM.—*Thenga nari pillu*; ORIYA—*Panda-suali.*

PUNJAB—*Champ, chhat, gandi, luinji*; UTTAR PRADESH—*Machaori, musial*; MADHYA PRADESH—*Bharwan, ghorayal, gonda, malwajari, masan*; BOMBAY—*Chamge, dangers, gandhi, masel, shata, tambit, tambrut.*

A tufted perennial grass, 1–3 ft. high, with erect, slender culms and narrow linear leaves, found nearly throughout India, up to an elevation of 2,500 ft. usually on low-lying, water-logged situations. It is frequently gregarious, thrives well on loamy, clayey and black cotton soils and is fairly drought-resistant. The grass is widely grown in Nellore (Andhra) and used as feed for the Ongole breed of cattle. The grass is propagated by seeds sown broadcast (4–6 lb./acre) at the beginning of

FIG. 144. ISEILEMA LAXUM

the monsoon. It stands cutting well. It stands three cuttings in a year and yields up to 10,000 lb. of fodder per acre. The grass is a suitable cover for protecting earthen banks, water ways and trenches from erosion [Rege & Srinivasan, *Indian Fmg, N.S.*, 1956–57, **6**(7), 39; Jacob, *Madras agric. J.*, 1940, **28**, 63; Mudaliar, 534].

*I. laxum* is considered to be one of the best fodder grasses and is relished by cattle and horses both in the green state and as hay. It retains its nutritive value till the flowering stage. Analyses of grass (from Nagpur) at the young and flowering stages gave the following values (dry basis): crude protein, 5.67, 5.44; ether extr., 2.74, 3.31; crude fibre, 28.03, 34.04; N-free extr., 51.78, 48.22; total ash, 11.78, 8.99; silica, 6.70, 5.51; calcium (CaO), 1.30, 0.84; phosphorus ($P_2O_5$), 0.63, 0.59; potassium ($K_2O$), 1.45, 1.00; sodium ($Na_2O$), 0.30, 0.35; magnesium (MgO), 0.71, 0.47; and chlorine, 0.45, 0.36% respectively; copper and cobalt are present. Feeding trials have shown that nitrogen and mineral balances are positive. The hay (digestible protein, 2.34; and starch equivalent, 32.64 lb./100 lb. of dry matter) compares favourably with the hays of jowar and spear grass (*Heteropogon contortus* Roem. & Schult.) (Bor, *Indian For. Rec., N.S., Bot.*, 1940, **2**, 149; Nath & Das, *Indian J. vet. Sci.*, 1953, **23**, 43; Datta & Datta Biswas, *Indian J. agric. Sci.*, 1951, **21**, 93; *Annu. Rep. imp. vet. Res. Inst., Mukteswar & Izatnagar,* 1946–47, 17).

**I. prostratum** Anderss. syn. *I. wightii* Anderss.

D.E.P., IV, 524; III, 423; Fl. Br. Ind., VII, 218; Blatter & McCann, Pl. 73.

Tel.—*Yerra kala kasuvu.*

Punjab—*Ganni*; Uttar Pradesh—*Gandel*; Madhya Pradesh—*Buri, chhoti garpa, ghania, ghod, ghora mushan, mushad, ukri*; Bombay—*Achi grass, gandeli, gandhi, mabil, mussan, sona, tambit, tambrut.*

A tall, tufted perennial grass, 3–4 ft. high, with culms, often prostrate, rooting at the base. Leaves 4–8 in. long, narrow, smooth or scaberulous. The grass is found almost throughout India in damp, low-lying, swampy or marshy areas. It grows on heavy and light soils and on metamorphic rocks; in black cotton soils it is gregarious. The grass resembles *I. laxum* and is usually found in association with the latter; it can be recognised by the reddish colour of the leaves and stems. It is considered by some to be a fair fodder for cattle in the flowering and preflowering stages; others regard it as useless because of its pungent and unpleasant odour, especially in the fresh stages. It makes a fine hay. Analysis of the young grass gave the following values (dry basis): crude protein, 4.58; ash, 12.40; insol. residue, 9.02; calcium (CaO), 0.38; phosphorus ($P_2O_5$), 0.09; magnesium (MgO), 0.36; sodium ($Na_2O$), 0.30; and potassium ($K_2O$), 1.03% (Witt, 240–41; Haines, 1916, 267; Burns *et al., Bull. Dep. Agric. Bombay*, No. 78, 1916, 10; Lander, *Misc. Bull. Indian Coun. agric. Res.*, No. 16, 1942, 50).

## ISONANDRA Wight (*Sapotaceae*)

D.E.P., IV, 532; Fl. Br. Ind., III, 538.

A genus of laticiferous trees distributed in South India, Ceylon and parts of Malaysia. Four species occur in India.

*I. perrottetiana* A. DC. syn. *I. candolleana* Wight; *I. alphonseana* Dubard is a medium-sized tree

occurring in the evergreen forests of western ghats at altitudes of 2,000–7,000 ft. Young branches rusty tomentose; leaves alternate, elliptic-lanceolate to obovate-oblong, very variable; flowers small, subsessile, in axillary clusters; fruit an ellipsoid berry. The wood (wt., 48–58 lb./cu. ft.) is reddish brown, hard and close-grained; it is employed locally for door panels of huts (Gamble, 445).

*I. lanceolata* Wight syn. *I. wightiana* A. DC. is a tree closely related to *I. perrottetiana* and distributed in the same area. Its wood is hard, heavy, close-grained and durable; it is suitable for posts and rafters (Lewis, 246).

**ISOPYRUM** Linn. (*Ranunculaceae*)

Fl. Br. Ind., I, 23.

A genus of herbs distributed in the north temperate zone. Three species occur in India.

*I. thalictroides* Linn. is a small herb found in parts of north-west temperate Himalayas. Rootstock horizontal, fibrous or scaly; stems slender, 4–8 in. long; radical leaves 2–3 ternate: leaflets 2–3 lobed, cuneate at the base, membranous; cauline leaves alternate, 3-lobed or 3-foliolate; flowers 0.5 in. diam., hooded, clawed, in terminal panicles.

The rootstock and roots of the herb contain isopyrine; the alkaloid is present, in a lower concentration, in the green aerial parts also, but is absent in the flowers; the latter yield hydrocyanic acid (Wehmer, I, 313; Henry, 775).

**Isotoma** — *see* **Laurentia**

**Ispaghul** — *see* **Plantago**

**Italian Millet** — *see* **Setaria**

**ITEA** Linn. (*Saxifragaceae*)

D.E.P., IV, 532; Fl. Br. Ind., II, 407.

A genus of shrubs or small trees distributed in south-east Asia, Japan and North America. Three species occur in India.

*I. nutans* Royle (Kumaon—*Garkath, chumli*) is a shrub or a small tree found in the outer Himalayas, from Indus to Nepal, up to an altitude of 6,000 ft. Bark greyish brown; leaves alternate, elliptic-oblong, 4–6 in. × 1.5–2.5 in., serrate; flowers small, white, in drooping racemes; capsule *c.* 0.2 in. long, 2-valved.

The wood (wt., 38 lb./cu. ft.) is pinkish, close-grained, moderately hard, with a pretty silver grain. It is useful for small turnery articles (Gamble, 329–30).

*I. chinensis* Hook. & Arn. (Khasi Hills—*Dieng-lametrit, dieng-tem-sro*) is a shrub or a small tree resembling *I. nutans*, found in Khasi and Jaintia hills at altitudes of 2,500–5,500 ft. Its fruit is considered stomachic in China [Cheo, *Bot. Bull. Acad. sinica*, 1949, **3**(3), 136].

**Ivory** — *see* **Elephant**

**Ivy** — *see* **Hedera**

**Ivy Gourd** — *see* **Coccinia**

**Iwaarite** — *see* **Garnet**

**IXONANTHES** Jack (*Erythroxylaceae*)

Fl. Br. Ind., I, 416.

A small genus of trees and shrubs distributed in south-east Asia and New Guinea. One species occurs in India.

*I. khasiana* Hook. f. (Assam—*Theibar, selbal, thing-buphai*) is a moderate-sized to fairly large tree found in Cachar, Garo and Khasi hills. Trunk fluted at the base; bark thin, rough, greyish; leaves alternate, base decurrent into a short petiole, elliptic-lanceolate to oblong, 3–6 in. × 1.2–2.4 in.; flowers small, in panicles; capsule oblong, *c.* 1.5 in. long, 5-valved; seeds winged.

The wood is light brown, even-grained and ornamental in appearance. It takes a fine polish and is suitable for cabinet work (Fl. Assam, I, 186).

**IXORA** Linn. (*Rubiaceae*)

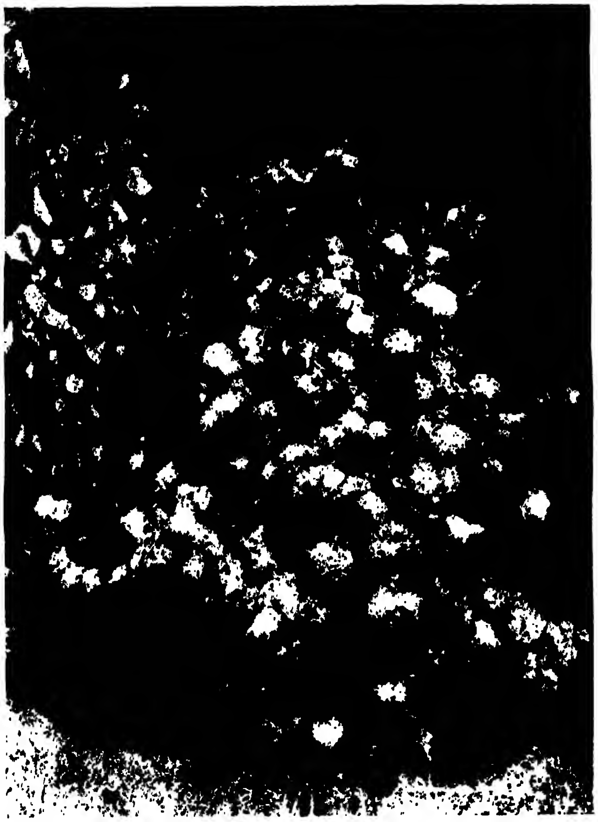
A genus of shrubs and small trees distributed in the tropical and sub-tropical regions of the world. About 30 species occur in India; a large number of exotics are cultivated in gardens.

Ixoras are popular garden plants grown for their beautiful clusters of flowers of various hues and evergreen foliage. They flower throughout the greater part of the year, but are most attractive during summer and rains. They grow well in all types of soils and can be raised by seeds, cuttings or layerings during the rains. They are suitable for growing in tubs or big pots. Application of liquid manure during flowering and close pruning after blooming are beneficial. The flowers retain their freshness for long and are valued as cut flowers.

**I. arborea** Roxb. syn. *I. parviflora* Vahl Torchwood Ixora

D.E.P., IV, 533; III, 415; Fl. Br. Ind., III, 142.

Sans.—*Iswara, nevali*; Hindi—*Kotagandhal, nevari*; Beng.—*Rangan*; Mar.—*Nevali, raikura,*



*F.R.I., Dehra Dun. Photo : M. N. Bakshi*

FIG. 145. IXORA ARBOREA—IN FLOWER

*likandi, mekadi* ; GUJ.—*Nevari* ; TEL.—*Korivipala, puttupala, kachipadel, gorivi* ; TAM.—*Shulundu-kora, korivi* ; KAN. *Gorabikattige, kansuragi* ; ORIYA—*Kilakrya, telokrya.*

A small, much-branched evergeen tree or shrub, found throughout the greater part of India, from the Gangetic plains eastwards to Assam and southwards to Kerala and in Nicobar Islands ; it is also grown in gardens. Leaves opposite, sub-sessile, oblong, elliptic or ovate-oblong, 3–6 in. long, coriaceous, glaucous ; flowers in large corymbose terminal cymes, small, numerous, white or pinkish, fragrant : berries black, globose, 0.25 inch in diam., somewhat didymous ; seeds plano-convex.

The fruits and roots are reported to be used by Santals as an antidote for coloured urine. The flowers are pounded in milk and given for relieving whooping cough. A decoction of the bark is used for anaemia and general debility. The ripe fruit is eaten by Santals and the leaves are used as fodder for buffaloes (Nadkarni, I, 700).

The wood is brown, hard and heavy (wt., 57–66 lb./cu. ft.), close-grained and smooth. It takes a good polish and is suitable for engraving and turning. Though available only in small sizes, it has been reported to be used for furniture and building purposes. It is also used as fuel ; the twigs burn freely and are employed for torches (Benthall, 283 ; Gamble, 421).

**I. coccinea** Linn. JUNGLEFLAME IXORA

D.E.P., IV, 533 ; Fl. Br. Ind., III, 145 ; Bor & Raizada, Pl. 28.

SANS.—*Raktaka, bandhuka* ; HINDI & BENG.—*Rangan, rookmini, rajana* ; MAR. *Pendgul, bakora* ; TEL.—*Koranam, mankana* ; TAM. *Chetti, kullai, vedchi* ; MAL.—*Thechii, thetti* ; KAN.—*Kepala, kisukare* ; ORIYA—*Bondhuko, romoniphulo.*

A shrub or a small tree occurring along the western coast and widely grown in gardens throughout India for ornament. Leaves opposite, sessile or nearly so, elliptic, ovate or obovate, 2–4 in. long, apiculate, obtuse or mucronate, coriaceous, glaucous ; flowers in dense terminal corymbose cymes, numerous, bright scarlet, sometimes yellow ; berries globose, reddish, c. 0.25 in. diam ; seeds concave. The fruits are eaten and the flowers are used as a flavouring (Rama Rao, 213 ; Burkill, II, 1261).

The roots exude a yellow juice and give out a disagreeable rancid odour. They are reported to possess sedative and stomachic properties and are used in hiccup, fever, gonorrhoea, loss of appetite, diarrhoea and dysentery. They are also reported to stimulate gastric secretions and bile, and to provide relief in abdominal pain. The roots possess astringent and antiseptic properties and are applied to sores and chronic ulcers, and also in headache. The flowers are used in the treatment of dysentery, leucorrhoea, dysmenorrhoea, haemoptysis and catarrhal bronchitis. A decoction of the flowers or the bark is employed as a lotion for eye troubles and for sores and ulcers. The leaves are used in diarrhoea (Dymock, Warden & Hooper, II, 213 ; Quisumbing, 913 ; Burkill, II, 1261 ; Kirt. & Basu, II, 1289 ; Cowen, 110 ; Nadkarni, I, 699).

The roots are reported to contain an acrid aromatic oil, tannin, fatty acids and a white crystalline substance. The root bark contains $\Delta$-9, 11-octadecadienoic acid, mannitol and myristic acid. A yellow colouring matter related to quercitrin, an astringent principle, a wax and a neutral crystalline substance (m.p., 257°) have been isolated from the flowers (Nadkarni, I, 699 ;

Kartha & Menon, *Proc. Indian Acad. Sci.*, 1943, **17A**, 11 ; Varghese, *Proc. Indian Sci. Congr.*, pt III, 1956, 131).

The wood is hard, tough and durable and suitable for tool handles (Lewis, 235).

*I. acuminata* Roxb. (NEPAL—*Chewaripat* ; ASSAM—*Thekeria*) is a shrub with elliptic or linear-oblong leaves and white fragrant flowers, found in eastern Himalayas and Assam, up to an altitude of 4,000 ft. The plant is reported to be used as a mordant along with annatto dye (from the seeds of *Bixa orellana* Linn.).

*I. chinensis* Lam. is an ornamental shrub closely resembling *I. coccinea*. It is a native of China and Malaysia and is grown in Indian gardens for its dense clusters of flowers varying in shade from white and yellow to pink and scarlet. In Philippines, an infusion of fresh flowers is considered beneficial in incipient tuberculosis and haemorrhages. In Malaya, the plant is used in urinary troubles and a decoction of the root is administered after childbirth (Bor & Raizada, 90 ; Quisumbing, 912 ; Burkill, II, 1261).

*I. cuneifolia* Roxb. is an evergreen shrub with white flowers, occurring in Sylhet and Assam and in Wynaad, Atamalai and Anamalai hills in the south. In Indo-China, an infusion of the leaves is used as a febrifuge (Kirt. & Basu, II, 1289).

*I. grandifolia* Zoll. & Moritzi is a shrub or a tree with large petioled, elliptic-ovate or lanceolate leaves and white or pinkish flowers, occurring in Andaman and Nicobar islands. In Malaya, the leaves are administered to pregnant women to facilitate delivery. An infusion of the leaves is reported to relieve stomach-ache (Burkill, II, 1262)

*I. lobbii* Loud. is a shrub grown in some Indian gardens. In Malaya, a poultice prepared from the root is applied in headache and a decoction of the root is given before and after delivery, and possibly also in diarrhoea (Burkill, II, 1262).

*I. nigricans* R. Br. ex Wight & Arn. (MAR. *Katkura* ; TAM.—*Mashagani, udappu* ; KAN. *Adayala*) is a handsome evergreen shrub or a small tree with elliptic-oblong or lanceolate membranous leaves and white fragrant flowers, occurring in westetrn ghats from Konkan southwards and in the hills of Assam. The leaves are considered to have antidysenteric properties (Kirt. & Basu, II, 1290).

*I. notoniana* Wall. (TAM. *Katilambili* ; MAL. *Irambaruppi*) is a shrub or a small tree occurring in Anamalai, Nilgiri and Pulney hills and in the hilly parts of Mysore and Kerala. The wood is used as fuel (Rama Rao, 212).

# J

## JACARANDA Juss. (*Bignoniaceae*)

A genus of trees and shrubs, native of tropical America. A few species are cultivated in Indian gardens for ornament.

***J. acutifolia** Humb. & Bonpl. syn. *J. mimosifolia* D. Don ; *J. ovalifolia* R. Br.

Blatter *et al.*, 93. Pl. XVIII.

An elegant shrub or medium-sized tree, commonly cultivated in Indian gardens for its finely divided foliage and beautiful flowers. Leaves alternate or almost opposite, bipinnate: pinnae in many pairs, each with 10–24 or more pairs of oblong-rhomboid leaflets with the end one larger ; flowers bluish violet, in loose panicles ; fruit an oblong, ovoid or broad capsule.

The plant thrives in well-drained soil and does not tolerate damp situations. Propagation may be done with transplants raised from seeds or cuttings of half-ripe shoots. It stands pruning well, recovers rapidly from frost damage and is useful for avenues. It is affected by white spongy rot caused by *Polystictus hirsutus* Fr. (*Indian J. agric. Sci.*, 1950, **20**, 107).

In S. America, the bark and leaves of the plant are used for syphilis and blennorrhagia. An infusion of the leaves is given as a pectoral and powdered leaves are used as a vulnerary. An infusion of the bark is employed as a lotion for ulcers (Blatter *et al.*, 94).

* Some authors consider *J. acutifolia* Humb. & Bonpl. as distinct from *J. mimosifolia* D. Don syn. *J. ovalifolia* R. Br. (Chatterji, *Bull. bot. Soc. Beng.*, 1948, **2**, 77).

F.R.I., Dehra Dun. Photo : C. E. Parkinson

FIG. 146. JACARANDA ACUTIFOLIA—FLOWERING BRANCH

The wood is beautiful, fragrant, moderately hard and heavy and fine-textured. It is easy to work and useful for tool handles (Colthurst, 99; Parry, *E. Afr. agric. J.*, 1953–54, **19,** 154 : Record & Hess, 81).

*J. acutifolia* is a host plant for the Indian lac insect. The flowers contain an anthocyanin, probably hirsutidin diglycoside (Kapur, *J. Bombay nat. Hist. Soc.*, 1954 55, **52,** 645 : Ponniah & Seshadri, *J. sci. industr. Res.*, 1953, **12B,** 605).

*J. rhombifolia* G.F.W. Mey. syn. *J. filicifolia* D. Don is a slender, deciduous tree grown in Indian gardens for its fern-like papyraceous foliage and purplish violet flowers. Unlike *J. acutifolia* it can stand damp situations. Its wood is whitish in colour, hard, light (sp. gr., 0.40–0.50 : wt., 25–31 lb./cu. ft.), medium- to coarse-textured and straight-grained. It is easy to work, gives a smooth finish and holds nails firmly, but is perishable in contact with the ground. Extracts of the plant show insecticidal properties (Benthall, 344 ; Record & Hess, 82 ; Sievers *et al.*, *J. econ. Ent.*, 1949, **42,** 549).

Several species of *Jacaranda* are employed in syphilis in Brazil and other parts of South America under the names caroba, carabinha, etc. A crystalline substance, carobin, besides resins, acids and caroba balsam, has been isolated from them (U.S.D., 1947, 1493).

**Jackals** — *see* **Dogs, Wolves, Jackals, Foxes and Wild dogs**

**Jack Bean** — *see* **Canavalia**

**Jack Rabbits** — *see* **Rodents**

**Jack Tree** — *see* **Artocarpus**

## JACQUINIA Linn. (*Myrsinaceae*)

Chittenden, II, 1083.

A small genus of evergreen shrubs and trees, distributed in tropical America and West Indies. A few species have been introduced into India and occasionally grown in gardens.

*J. barbasco* (Loefl.) Mez syn. *J. armillaris* Jacq. (Bracelet Wood) is a shrub or tree with wedge shaped, spathulate or obovate-oblong leaves and white flowers ; fruit a berry containing several shining yellow and brown seeds. The plant is said to be poisonous and used as an ingredient of arrow poison. The seeds are made into bracelets in West Indies (Benthall, 285 : Burkill, II, 1264).

## JADE

The term jade is applied to two distinct minerals, Jadeite and Nephrite, both of which are semi-precious stones of great charm. Jade is translucent and tough, and a properly cut stone, when struck, emits a musical note which is maintained for a fairly long time. Nephrite has been known since the earliest times, while jadeite was discovered in 1868. The term jade is sometimes loosely applied to minerals with somewhat superficial resemblance to true jade. Some of them are: Uvarovite, Vesuvianite and its green variety Californite, Sillimanite, Pectolite, Bowenite and Saussurite. These minerals can be readily distinguished from true jade by their physical and chemical properties.

Jadeite (sp. gr., 3.33 : H., 6.5–7) is a metasilicate of sodium and aluminium [$Na_2O.Al_2O_3.4SiO_2$ or NaAl

$(SiO_3)_2]$ associated, in its natural state, with small quantities of iron, calcium and magnesium. Pure jadeite is white in colour, but due to the presence of varying amounts of iron, the natural stone exhibits different shades of green ; a dark green to nearly black variety (CHLOROMELANITE) contains iron sesquioxide (iron, *c.* 10%). In chemical composition and crystalline characters, jadeite belongs to the pyroxene group of minerals. Jadeite is commonly granular, rarely fibrous. The individual grains are sometimes prismatic in shape and equi-dimensional.

Nephrite (sp. gr., 2.96–3.1 ; H., 6–6.5) is a silicate of calcium and magnesium ($CaO.3MgO.4SiO_2$) associated, in its natural state, with small quantities of impurities, notably iron, which impart to it varying shades of colour, from white (TREMOLITE) to dark green (ACTINOLITE). It has a glistening, sometimes oily lustre and breaks with a splintering fracture. The structure of nephrite is characteristically fibrous, the fibres being arranged in twisted, tufted, interlocked and other intricate patterns.

Table 1 gives the chemical composition of nephrite, jadeite and chloromelanite.

There are only a few places in the world where jade is known to occur. Burma is the sole producer of jadeite, the main area of its occurrence being the Kamaing sub-division in Myitkyina district (25°28′ & 25°52′ N. lat.: 96°7′ & 96°24′ E. long.). It is obtained from the outcrop mines of Tawmaw and detrital boulder workings. Jadeite occurs in small quantities in Tibet and in Shensi and Yunan provinces of

TABLE 1—CHEMICAL COMPOSITION OF JADE (%)*

| | Nephrite | Jadeite | Chloromelanite |
|---|---|---|---|
| $SiO_2$ | 58.00 | 58.24 | 56.12 |
| $Al_2O_3$ | 1.30 | 24.47 | 14.96 |
| CaO | 13.24 | 0.69 | 5.17 |
| $Na_2O$ | 1.28 | 14.70 | 10.99 |
| MgO | 24.18 | 0.45 | 2.79 |
| $Fe_2O_3$ | .. | 1.01 | 3.34 |
| $FeO_3$ | 2.07 | .. | 6.54 |
| $TiO_2$ | .. | .. | 0.19 |
| MnO | . | .. | 0.47 |
| $K_2O$ | .. | 1.55 | Trace |
| | 100.07 | 101.11 | 100.57 |

*Encyclopaedia Britannica, XII, 863.

China. Nephrite is found in Alaska (U.S.A.), Siberia, South Turkestan (U.S.S.R.) and New Zealand.

Mineral jade is reported to occur in a few localities in India, but the occurrences are of no commercial importance. Minerals resembling jadeite, notably sillimanite, occur associated with corundum deposits at Pipra in Rewa district, Madhya Pradesh (Mallet, *Rec. geol. Surv. India*, 1872, **5**, 20 : Sinor, *Bull. geol. Dep., Rewa State*, No. 1, 1923, 33).

So far marketable nephrite has not been found in India, but a mineral having the essential composition and approaching coarse jade in physical characters is known to occur in south Mirzapur, Uttar Pradesh (Clegg, *Rec. geol. Surv. India*, 1954, **80**, 402).

Jadeite is valued on the basis of its colour and translucency. The translucent variety, known as *Yay kyauk* in Burma, possessing a bright green colour resembling that of a peacock's tail, is most prized. A light green variety with bright spots and streaks, known as *Shwelu*, comes next. These two varieties are used in expensive jewellery. Pear-green and sage-green varieties are made into pipe stems, plates, cups and vases, bowls and other articles. Tablets of jadeite are used for decorative purposes as they develop a scenic beauty on polishing. Jadeite is used for decorating chairs, tables and other articles of furniture. The mineral is used in indigenous systems of medicine after subjecting it to a particular type of heat treatment.

The cutting and carving of jade is an extensive industry in China. In Srinagar, nephrite imported from South Turkestan is cut into earrings, ringstones, pendants, etc.

**Jaggery** — *see* **Borassus, Caryota, Cocos, Phoenix, Saccharum**

**Jaipurite** — *see* **Cobalt**

**Jalap** — *see* **Exogonium**

**Jambu, Jambul** — *see* **Syzygium**

**Japanese Raisin Tree** — *see* **Hovenia**

**Jarosse** — *see* **Lathyrus**

**Jarul** — *see* **Lagerstroemia**

**Jasmine, Cape** — *see* **Gardenia**

## JASMINUM Linn. (*Oleaceae*)

A large genus of climbing, trailing or erect shrubs, widely distributed in the warmer parts of the world. The distribution of the genus is pan-tropical, but a large number of species are centred round the area

comprising the Himalayas, China and Malaysia. About 40 species are recorded in India; many of them are cultivated for their handsome foliage and fragrant flowers; a few are grown for the extraction of Jasmine Oil, widely used in perfumery.

Many of the species recorded from India differ but slightly from one another and appear to be either varieties or cultivated forms of a few. Even among the well-known species, there are variants: many of them are horticultural selections based on flower size or fragrance and are vegetatively propagated; they have often been assigned specific or varietal epithets. As stated by Kobuski with respect to Chinese jasmines, a critical study of Indian species appears essential to evaluate specific identity (Kobuski, *J. Arnold Arbor.*, 1932, **13**, 145; 1939, **20**, 403).

Jasmines are fairly hardy, drought-resistant plants thriving well under both tropical and temperate conditions. Some of them have been introduced into the milder climates of Europe and have been found to stand temperatures as low as 50°F. In India, they are grown nearly throughout the country both in the plains and on the hills up to 10,000 ft. They grow in any soil, but give good results in rich loam or dry sandy soil with irrigation facilities; in clay soil, the vegetative growth is vigorous, but flower production is low, while in gravelly soil, the plants become stunted. Jasmine flowers and buds are in great demand and for this reason the plants are cultivated in small holdings, round outskirts of cities and towns. They are also grown in gardens, parks and homeyards (Bor & Raizada, 217; Dhingra, 25; Ratnam, *Madras agric. J.*, 1937, **25**, 15; *Bull. imp. Inst., Lond.*, 1947, **45**, 17; Gupta & Chandra, *Econ. Bot.*, 1957, **11**, 178).

The plants are propagated by cuttings, layering or suckers. Since many of the species and varieties are stragglers the plants need the support of a scaffold, pergola or a nearby tree.

Of the species with fragrant flowers, only three or four are commercially important as sources of fresh flowers or for the extraction of perfume. These are: *J. auriculatum*, *J. flexile*, *J. officinale* (including forma *grandiflorum*) and *J. sambac*.

Cultural practices with regard to the raising of jasmines vary with the type of soil and climatic conditions. They are usually planted in well prepared beds or pits, 4–9 ft. apart, and manured with cattle or farmyard manure. Artificial manures are not generally applied, though in France and other western countries small quantities of ammonium sulphate are added along with irrigation water. The plants do not require much attention after they are well established. Pruning is done to prevent the plants from developing into untidy bushes and also to induce profuse flowering in early summer. During intervals of flowering, the soil is dug up, the roots are exposed, shoots pruned, manure added and refilled, and plants watered so that dormant buds sprout out vigorously (Dhingra *et al.*, *Indian Soap J.*, 1950–51, **16**, 235; *Perfum. essent. Oil Rec.*, 1953, **44**, 11; Gupta *et al.*, ibid., 1951, **42**, 369; Ratnam, loc. cit).

In India, the flowers are generally harvested when the buds are developed, but still unopened. They are gathered in the evening before sunset and kept in a cool place; they open out by early morning. For extracting the perfume, the flowers are gathered slightly before or at daybreak. Flowering starts in early summer and continues till October or November; the flowering period comprises well defined subperiods of profuse flowering lasting about a week or so.

The bulk of flowers collected is used for garlands, chaplets, and bouquets, and for religious offerings. A small portion is used for the production of perfumed hair oils and attars, particularly in U.P. In Europe and in countries of the Mediterranean region, large quantities of jasmine flowers (from *J. officinale* forma *grandiflorum*) are utilised for the manufacture of jasmine oil. The odour of jasmine flowers is unique, in that it cannot be imitated by any known synthetic aromatic chemicals or natural isolates.

All parts of the plant contain mannitol. Green stems and leaves contain glucosides which are hydrolysed by emulsin, but do not yield odorous compounds (*Chem. Abstr.*, 1952, **46**, 8203; *Rep. ess. Oils Schimmel*, 1947–48, 83).

**J. angustifolium** Vahl  WILD JASMINE

D.E.P., IV, 541; Fl. Br. Ind., III, 598; Kirt. & Basu, Pl. 591.

SANS.—*Asphota, kananamallica, vanamalli;* HINDI—*Banmallica, mwari;* TEL.—*Adavimalle, chirumalle;* TAM.—*Kattumalligei, kattumullai;* KAN.—*Kadumallige, vanamallige;* MAL.—*Kattumalliga.*

A small scandent shrub found in the lower hills of S. India, commonly in the Circars, Deccan and Carnatic down to Travancore. Stem glabrous; branchlets minutely pubescent; leaves simple, very variable even on the same plant, acute, base obtuse or almost rounded, glabrous; flowers exquisitely fragrant, white and star-like, either solitary or more

usually in threes ; corolla lobes 7 or 8, linear, obtuse, very acute ; carpels two usually well developed.

The plant grows easily in every soil and situation. It bears bright, shining and deep green showy foliage, and is particularly well-adapted for screening windows and for arbours. It flowers in profusion during the hot weather and is a delightful plant for perfuming the verandah (Burns & Davis, 61 : Firminger, 460).

The bitter root is used in external applications for ringworm. The juice of leaves is given as an emetic in cases of poisoning (Kirt. & Basu, II, 1520 : Rama Rao, 246).

**J. arborescens** Roxb. syn. *J. roxburghianum* Wall. TREE JASMINE

D.E.P., IV, 541 ; Fl. Br. Ind., III, 594 ; Kirt. & Basu, Pl. 590.

SANS.—*Saptala, navamallica;* HINDI—*Bela, chameli, mutabela* ; BENG.—*Bura kunda, nab-mallica* ; TEL.—*Adavimalle* ; TAM.—*Nagamalli* ; ORIYA—*Bonomali.*

SANTAL.—*Gadahundbaha.*

A large sub-erect or climbing shrub with hairy branchlets, distributed along the sub-Himalayan tract and outer ranges up to an altitude of 4,000 ft. and in Bengal, Chota Nagpur, Orissa and hills of Ganjam, Visakhapatnam and Bellary. Leaves simple, opposite, shortly acuminate, often tomentose on both surfaces ; cymes with 12–20 flowers, not dense ; flowers white and very fragrant ; carpels single, ellipsoid, black.

This species is common in sal and miscellaneous forests throughout the sub-Himalayan tract and along the rocky hillsides and *nalas* in Chota Nagpur. It is a variable species ; *J. roxburghianum* Wall., a species recorded from Bihar and parts of Deccan is considered to be no more than a variety of this species. The plant is reported to be susceptible to stem blight caused by *Dendrophoma jasmini* Syd. and *Microdiplodia jasmini* Syd., leaf spot caused by *Fusicladium butleri* Syd. and leaf and stem rust caused by *Uromyces hobsoni* Vize. (Osmaston, 334 : Haines, IV, 525 ; *Indian J. agric. Sci.*, 1950, **20**, 107).

The flowers yield a volatile oil. The juice of the leaves is used with pepper, garlic and other stimulants as an emetic in obstructions of bronchial tubes. The leaves are slightly bitter and astringent and used as tonic and stomachic. A preparation of the plant is reported to be prescribed by Santals in certain menstrual complaints. The Oraons use the berries as a tonic. The seeds are said to be eaten in times of scarcity (Kirt. & Basu, II, 1519 ; Bressers, 88 ; Rama Rao, 246).

FIG. 147. JASMINUM AURICULATUM—FLOWERING BRANCH

**J. auriculatum** Vahl

Fl. Br. Ind., III, 600.

SANS.—*Juthika, mugdhee, suchimallika* ; HINDI—*Juhi, jui* ; BENG.—*Umbustha, gunica, yodthika* ; TEL.—*Adavimolla, ettadavimolla* ; TAM.—*Usimalligai* ; KAN.—*Kadarmallige, madhyanamallige vasantamulle* ; ORIYA—*Bonomollika, jui.*

A scandent, pubescent or villous shrub found in the Deccan Peninsula, Circars and Carnatic, extending southwards to Travancore. Leaves mostly simple, occasionally trifoliolate, the two lower leaflets small or reduced to auricles or frequently wanting ; flowers white, sweet scented, borne in pubescent, compound, many-flowered and lax cymes ; corolla lobes 5–8, elliptic ; carpels solitary, globose, black.

The plant is cultivated throughout India for its fragrant flowers particularly in U.P., Bihar and Bengal. In U.P., it is cultivated on a commercial scale in Ghazipur, Jaunpur, Farrukhabad and Kanauj (Table 1). It is propagated by cuttings planted during November–January. The flowers appear during the rainy season, about the beginning of August. They are small and light (26,000 flowers per kg.). The average yield of flowers varies from 37 to 75 kg. per

acre. The plant is reported to be susceptible to sooty mould caused by *Meliola jasminicola* P. Henn. (Dhingra, 26; *Indian J. agric. Sci.*, 1950, **20**, 107).

In India, *juhi* flowers are used for the production of perfumed hair oils and attars. The methods of production are similar to those employed for *J. officinale* forma *grandiflorum* (q.v.). The yields and properties of concrete and otto, produced from the flowers on an experimental scale at Kanpur, are summarised in Tables 2 and 3. The otto has a dark red colour and an odour similar to that of fresh flowers, more pleasant and delightful than that of ottos from other *Jasminum* spp. It contains: esters (as benzyl acetate), 35.7; alcohols (as linalool), 43.81; indole, 2.82; and methyl anthranilate, 6.1% (Gupta *et al.*, *Perfum. essent. Oil Rec.*, 1951, **42**, 369).

The flowers are reported to have medicinal properties and are given in consumption (Kirt. & Basu, II, 1925).

**J. flexile** Vahl (including *J. caudatum* Wall.)

Fl. Br. Ind., III, 601.

Beng.—*Malati*; Tam.—*Ramabanam mullai*; Kan. —*Nityamallige*.

Khasi—*Mei-long-kaitsree, mei-soh-siang*.

A large climber found in Assam, Aka, Lushai and Khasi hills, lower hills of Deccan and in western ghats up to an elevation of 5,000 ft. Bark whitish; leaves opposite, usually trifoliolate: terminal leaflet 2–4 in. long, base rounded or obtuse, lateral ones rather small; flowers in slender lax panicles; corolla lobes, white, acute or obtuse; carpel ellipsoid.

This species is very variable. Three varieties are distinguished, viz. var. *travancorense*, var. *ovata* and var. *hookeriana*. Var. *travancorense* is distributed in the west coast from S. Kanara to Kerala at low elevations, while the other two are recorded respectively from Khasi and Lushai hills. *J. caudatum* Wall., a species recorded from Bihar, Bengal, Khasi, Jaintia, Lushai hills and Andaman Islands, is considered to be closely similar to var. *hookeriana* and better united under the name *J. flexile* [Fl. Madras, 791; Fl. Assam, III, 231–32; Fischer, *Rec. bot. Surv. India*, 1938, **12**(2), 110; Haines, IV, 526].

The plant is cultivated for its scented flowers. It flowers nearly throughout the year, but in the cooler months, the flowering is profuse. The flowers resemble those of *J. officinale* forma *grandiflorum*, but are considered inferior to them in fragrance (Ratnam, loc. cit.; Krishnaswamy & Raman, *J. Indian bot. Soc.*, 1948, **27**, 77).

This plant is practically free from any insect pest. Infestation by *Ricania fenestrata* Fabr. resulting in disfiguration and drying up of affected parts has been reported in Bangalore; dusting with 5% benzene hexachloride powder on nymphs and adults was effective in controlling the pest (Puttarudriah & Maheswariah, *Mysore agric. J.*, 1954, **30**, 12).

The bark of the stem is reported to contain a bitter glucoside and a colouring matter (Dymock, Warden & Hooper, II, 380; Wehmer, II, 957).

**J. humile** Linn. syn. *J. inodorum* Jacq.; *J. revolutum* Sims; *J. chrysanthemum* Roxb.; *J. wallichianum* Lindl.; *J. pubigerum* D. Don *β. glabrum* DC.; *J. bignoniaceum* Wall. Yellow Jasmine, Italian Jasmine, Nepal Jasmine

D.E.P., IV, 543; Fl. Br. Ind., III, 602.

Sans.—*Svarnajuthica, hemapushpika*; Hindi—*Peeli chameli, peelajui, malto*; Beng.—*Svarnajui*; Tel.—

*Bot. Dep., Pres. College, Madras*

FIG. 148. JASMINUM HUMILE VAR. BIGNONIACEUM—FLOWERING BRANCH

JASMINUM HUMILE — FLOWERING BRANCH

*Pachche adavimalle*; TAM.—*Semmalligai*; KAN.—*Hasarumallige*; MAL.—*Ponmallika*.

KUMAON—*Sonajahi*.

An erect diffuse shrub with glabrous, angular branches, found throughout the sub-tropical Himalayas from Kashmir to Nepal up to an altitude of 9,000 ft., and in Mount Abu and the hills of S. India above 5,000 ft. Leaves alternate: leaflets, 2–11, very variable in size; flowers yellow, fragrant, solitary or in short terminal compound corymbose cymes; corolla lobes 5, ovate or obtuse; carpels black when ripe with crimson juice.

The plants included under this species are very variable and are found distributed in India and China and have been recorded under more than half a dozen specific names. These specific names have all been merged under a single unit, *J. humile* in Fl. Br. India and in most of the later Indian floras, but often separately dealt with in horticultural literature. While a careful study of the Chinese and N. Indian variants have shown that it is possible to merge them in a single unit, it is still convenient to retain them as separate varieties, if not as species, due to considerable variation seen among them. An examination of the Indian material recorded under the specific name *J. bignoniaceum* Wall. indicates also that it is different from its N. Indian counterparts and that it should be considered as a distinct variety, if not as a species (Kobuski, *J. Arnold Arbor.*, 1932, **13**, 145; 1939, **20**, 403; Fyson, Flora of the Nilgiri & Pulney Hill tops, 1915, I, 276).

The plants are grown in gardens for their fragrant yellow flowers. They are easily propagated by seeds or cuttings. In Darjeeling, they bear flowers in profusion for a long period and set seed freely. The flowers yield an aromatic essential oil used in perfumery. A yellow dye is extracted from the roots. The root is said to be useful in ringworm. The milky juice exuded from incisions in the bark is effective in destroying unhealthy lining walls of chronic sinuses and fistulas (Bailey, 1947, II, 1719; Chittenden, II, 1087; Bor & Raizada, 222; Kirt. & Basu, II, 1521).

**J. malabaricum** Wight syn. *J. latifolium* Grah. non Roxb.

Fl. Br. Ind., III, 594; Talbot, II, 187, Fig. 384.

MAR.—*Kundi, kusur, kusuri*; KAN.—*Dolle kusdiballi, tirgal.*

BOMBAY—*Mogra, ran-mogra.*

A large climbing or scandent shrub, commonly found in Deccan, west coast and western ghats from Konkan southwards to Malabar and in Nilgiris up to 4,000 ft. Stem up to 8 inches in diam.: branches terete, glabrous; leaves broadly ovate, acute or acuminate at the apex, rounded or sub-cordate at the base, membranous, glabrous; flowers borne in terminal, lax, many-flowered (often 40–50) trichotomous cymes, white, fragrant; calyx lobes 5–7, linear; corolla lobes 6–10, oblong or lanceolate finely acuminate; carpels ellipsoid.

The plant is common in moist monsoon forests, and flowers profusely from February to May, occasionally up to June, and fruits from April to September. It is grown for its fragrant flowers, even though it has a wild look. It is reported to be affected by a leaf mould caused by *Asterina spissa* Syd., a rust caused by *Chaconia butleri* Syd. and a leaf and stem rust caused by *Uromyces hobsoni* Vize. (Santapau, *J. Bombay nat. Hist. Soc.*, 1946–47, **46**, 563; *Rec. bot.*

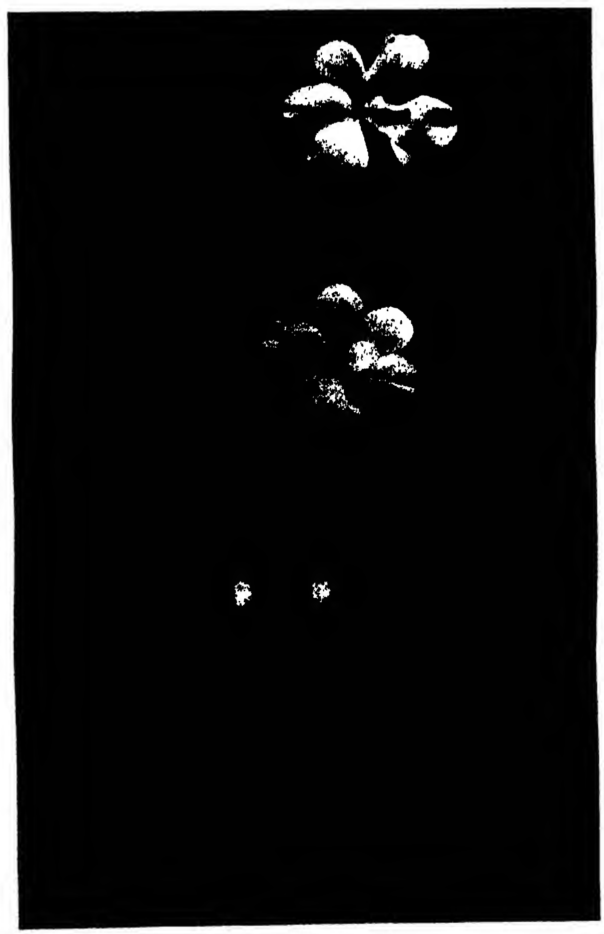


*Photo: Ramesh Bedi*

FIG. 149. JASMINUM MESNYI—FLOWERING BRANCH

*Surv. India*, 1953, **16**, 162 : *Indian J. agric. Sci.*, 1950, **20**, 107).

The juice of the stem is reported to be used for cataract in the eye (Kulkarni, *J. Bombay nat. Hist. Soc.*, 1909–10, **19**, 574).

**J. mesnyi** Hance syn. *J. primulinum* Hemsl. PRIMROSE JASMINE

Bailey, 1947, II, 1718 : Kobuski, *J. Arnold Arbor.*, 1932, **13**, 152.

An evergreen twiggy shrub, native of Yunnan (China), extensively cultivated throughout the tropical and sub-tropical parts of the world. Branches 4-angled, stiff and glabrous ; leaves opposite, 3 foliolate, up to 4 in. long : leaflets almost sessile, glabrous, narrowly elliptic or oblong-lanceolate, rather thick in texture, dark green and shining above and pale beneath ; flowers solitary, axillary, primrose-yellow in colour, orange at the throat ; calyx lobes 6, lanceolate ; corolla lobes usually 6, obovate, rounded.

This plant is not known in a wild state and has been grown as an ornamental plant for its large scentless flowers. It thrives on poor soil and under adverse conditions and can be propagated by layering, cuttings or root suckers ; double-flowered forms are also known under cultivation. The flowers appear in March-May (Bor & Raizada, 220-21).

**J. multiflorum** (Burm. f.) Andr. syn. *J. pubescens* Willd. : *J. hirsutum* Willd. DOWNY JASMINE

D.E.P., IV, 544 : Fl. Br. Ind., III, 592.

SANS.—*Kunda, sadapushpa, vasanta* ; HINDI—*Chameli, kunda, kundphul* ; MAR.—*Mogra* ; TEL.—*Gujari, kundamu, malle* ; TAM.—*Malligai* ; MAL.—*Kurukuttimulla*.

A large scandent, tomentose shrub with branches and young parts villous ; leaves opposite, simple, ovate, acuminate, more or less pubescent beneath ; flowers borne in compact, short, pedunculate cymes, slightly fragrant, white, sub-sessile ; corolla lobes oblong, lanceolate ; carpel black when ripe.

The plant is found throughout India and is common in the sub-Himalayan tract up to an elevation of 3,000 ft. and in moist forests of western ghats up to a height of 5,000 ft. It is very variable. It is not exacting in soil requirements and flowers practically throughout the year : flowering is particularly profuse during winter, when the flowers appear in bunches, sometimes as many as 30. The plant is exceedingly ornamental and is particularly well adapted for covering trellis or as ground cover and

FIG. 150. JASMINUM MULTIFLORUM—FLOWERING BRANCH

low shrub (Firminger, 462 ; Bor & Raizada, 220 ; Bhatnagar, *Sci. & Cult.*, 1956–57, **22**, 506).

Dried leaves of the plant are reported to be employed in poultices for indolent ulcers (Kirt. & Basu, II, 1518).

**J. officinale** Linn.

D.E.P., IV, 544 : Bor & Raizada, 222.

A twining shrub, with striate branches, considered to be a native of Persia or Kashmir where it occurs at an altitude of 3,000–9,000 ft. Leaves opposite, imparipinnately compound with 3–7 leaflets : terminal leaflet larger than laterals ; inflorescence terminal with few-flowered (at times single-flowered) cymes, shorter than leaves ; flowers white with 4–5 lobes, fragrant ; fruit elliptic globose, black when ripe.

The species is hardy and is cultivated nearly throughout the tropical and temperate regions of the world but often replaced by forma *grandiflorum*.

FIG. 151. JASMINUM OFFICINALE—FLOWERING BRANCH

--- — forma **grandiflorum** (Linn.) Kobuski syn. *J. grandiflorum* Linn. SPANISH JASMINE, COMMON JASMINE

D.E.P., IV. 542; Fl. Br. Ind., III. 603; Bor & Raizada, 223.

SANS.—*Chambeli, chetaki, jati, malati*; HINDI & BENG.—*Chameli, jati*; GUJ.—*Chambeli*; TEL.—*Jaji, malati*; TAM.—*Manmadabanam, mullai, padarmalligai, pichi*; MAL.—*Pichakam, pichakamulla*; KAN.—*Ajjige, jaji, mallige, jati mallige.*

PUNJAB—*Chamba, chambeli.*

A large scrambling or twining shrub, considered to be a native of N.W. Himalayas, widely grown in gardens throughout India. Branches ribbed; leaves opposite, imparipinnately compound: leaflets 7–11, terminal leaflet somewhat larger than laterals: lateral leaflets sessile or shortly petiolate, distal pair with broad connate bases confluent with the terminal; flowers borne in lax axillary or terminal cymes longer than leaves, white, often tinged with purple on the outside, delightfully fragrant; bracts ovate to spathulate-oblong, foliaceous; calyx glabrous: lobes 5, subulate; corolla lobes 5, elliptic or obovate: carpels 2.

This form is extensively cultivated both in the plains and on the hills up to an altitude of 10,000 ft. It is the chief source of the commercial perfume in Europe and Mediterranean countries and includes all the horticultural types of *J. officinale* grown in gardens, particularly those having large and showy flowers. It has often been designated as a distinct species, different from *J. officinale*. It differs from the latter mainly in its more vigorous growth, larger number of leaflets per leaf, shape and size of the inflorescence, which is longer than the leaves. The study of a large collection of samples, both spontaneous and cultivated, has shown that there is a definite gradation in all the diagnostic characters and that no character or group of characters held together permitted a specific separation. Both plants are widely grown in Europe, and forma *grandiflorum* is grafted upon the stalks of *J. officinale* to yield flowers which are used for perfume extraction. It is difficult to separate the information on one from the other and it has been found convenient to deal with them together (Kobuski, *J. Arnold Arbor.*, 1932, **13**, 145).

Various types of *J. officinale* and forma *grandiflorum* are grown in India, particularly in the vicinity of towns and cities, where flowers find a ready market. The plants are cultivated on a large scale in a few areas in U.P., for example in Ghazipur, Farrukhabad, Ballia and Jaunpur, and flowers are used for the extraction of perfume. Data relating to the acreage under cultivation or production of flowers are not available. Table 1 gives an estimate of the acreage and yield according to a survey carried

TABLE 1—ESTIMATED ACREAGE AND PRODUCTION OF JASMINE FLOWERS IN U.P.*

| | *J. auriculatum* | | *J. officinale* forma *grandiflorum* | | *J. sambac* | |
|---|---|---|---|---|---|---|
| | Acreage | Av. yield/acre (md.) | Acreage | Av. yield/acre (md.) | Acreage | Av. yield/acre (md.) |
| Farrukhabad | 1 | 1 | 50 | 7 | 92 | 10 |
| Ghazipur | 10 | 1 | 165 | 4 | 4 | 8 |
| Sikandarpur (Ballia dist.) | .. | .. | 19 | 6 | 3 | 10 |
| Jaunpur | 1.5 | 2 | 40 | 6 | 21 | 12 |

* Dhingra, 13.

out in U.P. The plants once established continue to yield flowers for 8–15 years.

The flowers vary in size, depending upon the age of the plant, cultural practices and season. The average yield of flowers per acre in U.P. ranges from 160–280 kg. (10,000–12,000 flowers per kg.). The maximum yield reported is 400 kg. per acre. An average yield of 1,600 kg. per acre has been reported in France; the yield reaches the maximum from the fifth year onwards after planting (Dhingra, 13, 26; *Bull. imp. Inst., Lond.*, 1947, **45**, 17).

*J. officinale* and forma *grandiflorum* are subject to leaf and stem rust, caused by *Uromyces hobsoni* Vize. A jasmine bug has been reported from South India; this can be controlled by spraying the bushes with fish oil resin soap mixture (*Indian J. agric. Sci.*, 1950, **20**, 107; Ratnam, loc. cit.).

The bulk of the harvested flowers is used as such in garlands, chaplets and decorative bunches and for religious offerings; only a small quantity is used for the production of hair oils and attars. There is no production of jasmine oil in India. Jasmine oil of commerce is almost entirely obtained from the flowers of this species in Grasse (France), Sicily and Calabria (Italy), which are the principal producers of the oil. In recent years, plantations have been started in Egypt, Syria, Algeria and Morocco (Guenther, V, 320).

The leaves also contain a resin, salicylic acid, an alkaloid (jasminine) and an astringent principle. The root is said to be used in the treatment of ringworm. In Catalonia and Turkey, the long straight stems of the plant are used for making slender pipe tubes. The leaves are chewed for relief in cases of ulceration of the mucous membrane of the mouth. Fresh juice of leaves is used as an application for corns; an oil preparation containing the juice is used in otorrhoea. The whole plant is considered to be anthelmintic, diuretic and emmenagogic. The scented oil and attar from flowers are valued for their cooling effect in skin diseases, headache and eye troubles (Kirt. & Basu, II, 1523).

### Jasmine Oil

Jasmine flowers owe their fragrance to a volatile oil present in the epidermal cells of the inner and outer surfaces of both the petals and the sepals. The flowers continue to emit the natural perfume even after they are detached from the plant, until they fade and deteriorate. The fragrance begins to develop when the flowers open out soon after sunset and within a few hours after sunrise, the formation of scent practically ceases, but the flowers continue to emit fragrance, on account of the essential oil formed during the night (Finnemore, 696; Rakshit, *Perfum. essent. Oil Rec.*, 1937, **28**, 241; Guenther, V, 325–26).

Jasmine perfume is extracted from the flowers by enfleurage or by solvent extraction; steam-distillation gives poor yields. As the development of perfume continues for sometime after gathering, the enfleurage process gives higher yields, nearly 2 to 3 times that obtained by solvent extraction. The latter process has, however, been found to be economical as it not only recovers practically all the odorous constituents but also saves labour charges. In the solvent extraction process, the flowers are placed in a battery of closed cylinders and the refined solvent is allowed to run through them in succession. Petroleum ether is the solvent usually employed; benzene produces a highly coloured product with a hard odour. The solvent is recovered by vacuum distillation and the residue, consisting of odorous principles and waxes, constitutes the concrete. The absolute is obtained by separating the waxy material by treatment with high proof alcohol (Poucher, II, 145; Guenther, V, 324, 332).

The enfleurage process was generally adopted, until recently, for the extraction of perfume, particularly in France. It is the method employed in India. In this process, the perfume is absorbed by a fatty body from which it is later recovered by alcohol, acetone or other solvent. In France, where this process has been in vogue for centuries, fresh flowers are gathered and placed on glass trays smeared with refined fat (lard or beef suet or a mixture of the two); the exhausted flowers are daily replaced by fresh flowers, till the fat becomes fully saturated with the perfume. The pomade obtained is extracted with alcohol and the extract distilled to give the absolute. Treated flowers, which still retain some perfume, are extracted with petroleum ether to yield a second-grade product (*Perfum. essent. Oil Rec.*, 1948, **39**, 351; *Bull. imp. Inst., Lond.*, 1947, **45**, 17).

The yield of concrete, according to Naves & Mazuyer varies from 0.28 to 0.34%. There is a 45–53% yield of absolute and a 10 to 19% content of steam distillable substances. The yield of absolute obtained by enfleurage is much higher. The yield and quality of the perfume depend upon several factors: flowers gathered from high altitudes give a product of superior quality; those gathered early in the morning yield more oil of a finer aroma than those picked at noon or in

JASMINUM OFFICINALE *FORMA* GRANDIFLORUM — FLOWERING BRANCH

TABLE 2—CHARACTERISTICS OF CONCRETES AND OTTOS FROM INDIAN JASMINUM SPP.

| | *J. auriculatum* | | *J. officinale* forma *grandiflorum* | | *J. sambac* | | |
|---|---|---|---|---|---|---|---|
| | | | | | Concrete[3] | | Otto[3] |
| | Concrete[1] | Otto[1] | Concrete[2] | Otto[2] | Benzene extr. | Chloroform extr. | |
| Yield, % | 0.412 | .. | 0.367–0.425 | .. | 0.44 | 0.44 | .. |
| Congealing pt. | 48° | .. | 54–55° | .. | 68–69° | 52° | .. |
| m.p. | 50° | .. | 54–55° | .. | 70° | 55° | .. |
| Sp. gr.$^{30°}$ | .. | 0.9548 | .. | 0.9814 (at 22°) | .. | .. | 0.9727–0.9797 |
| [α] | .. | .. | .. | +4.26° (at 20°) | .. | .. | .. |
| *n* | .. | 1.5185 | .. | 1.4970 (at 22°) | .. | .. | 1.506–1.507 (at 30°) |
| Acid val. | 9.5 | 7.2 | 0.23–0.27 | 1.16 | 3.76 | 9.7 | 1.51–11.36 |
| Ester val. | .. | 132.8 | .. | .. | .. | .. | 121.2–131.5 |
| Sap. val. | 230.46 | 140.04 | 116.2–119.6 | 278.06 | 176.7 | 165.9 | 126.7–141.0 |
| Sol. in 95% alcohol | .. | Sol. in all proportions (85% alcohol) | .. | .. | .. | .. | 1 in 9 (v/v) |
| Ester content, as benzyl acetate (%) | .. | 35.7 | .. | 74.8 | .. | .. | 32.45–35.2 |

[1] Gupta *et al.*, *Perfum. essent. Oil Rec.*, 1951, **42**, 369; [2] Dhingra *et al.*, ibid., 1953, **44**, 11; [3] Dhingra *et al.*, *Indian Soap J.*, 1950–51, **16**, 259.

the afternoon; those gathered in warm and sunny weather give a better yield and quality of perfume than those collected in cloudy or rainy weather. Flowers should be processed immediately after harvest and the temperature of extraction kept as low as possible (Naves & Mazuyer, 192; Poucher, II, 145; Guenther, V, 331–32).

Two types of extraction methods are followed in India, a modified enfleurage process for preparing perfumed oils and a distillation process for making attars. In the modified enfleurage process, cleaned and husked til (*Sesamum indicum*) seeds are used in place of lard or other fat; fresh jasmine flowers and til seeds are spread in alternate layers on the floor of a cemented pit; exhausted flowers are replaced by fresh flowers after every 10–12 hours until the seeds are saturated with the perfume. The perfumed oil, obtained from the seeds by expression in *ghanies*, is marketed as *Sire ka tel.* A total of 12–18 md. of flowers are used for 6 md. of seeds. Three types of perfumed oils are available, viz. *Sira* (high grade), *Baju* (medium grade), and *Raddi* (low grade). The exhausted flowers from *Sira* are used for the preparation of *Baju* and *Raddi* grade oils. No standards have been formulated for the oils.

For the production of attars, the flowers are distilled in earthenware vessels and the vapours absorbed in sandalwood oil. About 10 lb. of sandalwood oil are used for absorbing the perfume principles from 500–700 lb. of flowers. A superior grade of attar is obtained by ageing the product for 3–4 years, fresh jasmine extract being added every year during the ageing period (Narielwala & Rakshit, *Rep. essent. Oil Comm., Coun. sci. industr. Res.*, 1942, 24; Dhingra *et al., Indian Soap J.*, 1950–51, **16**, 235; Wlth India—Industrial Products, pt III, 211).

Experimental trials have been carried out at the H.B. Technological Institute at Kanpur on the pro-

TABLE 3—YIELDS OF OTTO FROM JASMINUM SPP. BY DIFFERENT EXTRACTION METHODS*

| | Water-distillation % | Steam-distillation % | Enfleurage % | Solvent extraction % |
|---|---|---|---|---|
| *J. auriculatum* | 0.020 | 0.030 | 0.146 | .. |
| *J. officinale* forma *grandiflorum* | 0.020–0.022 | 0.025–0.030 | 0.180 | 0.040 |
| *J. sambac* | 0.020–0.025 | 0.030–0.035 | 0.150 | 0.040 |

* Dhingra, 26.

duction of jasmine perfumes by enfleurage, solvent extraction, and direct distillation processes. The properties of concretes and ottos prepared are summarised in Table 2; the yield of otto varies with the species and the method of extraction (Table 3) (Dhingra *et al.*, *Indian Soap J.*, 1950–51, **16**, 235, 259; Gupta *et al.*, *Perfum. essent. Oil Rec.*, 1951, **42**, 369; Dhingra *et al.*, ibid., 1953, **44**, 11).

*Physico-chemical properties*—Concrete of jasmine obtained by solvent extraction is a waxy material, with red brown colour and characteristic odour of the flowers; it is partly soluble in 95% alcohol. Jasmine absolute is a viscous, clear, yellow-brown liquid with a delightful odour reminiscent of live flowers and soluble in 95% alcohol. The absolute darkens on ageing becoming deep red and deposits a greyish sediment. The absolute of enfleurage is a dark reddish brown, viscous oil with the scent of fresh flowers but with a fatty off-note. On ageing, it turns dark red and a sediment is deposited; the solubility in alcohol is also affected. The characteristics of jasmine concrete and absolute and of steam-volatile oils derived from them are summarised in Table 4.

*Composition*—Benzyl acetate is the principal constituent of jasmine oil. Other constituents reported to be present are: linalyl acetate, benzyl benzoate, benzyl alcohol, geraniol, nerol, *l*-α-terpineol, *d*- and *dl*-linalool, an alcohol(?) with an odour reminiscent of β, γ-hexenol, farnesol, nerolidol, an unidentified alcohol ($C_{18}H_{31}O$) which plays an important role in the fixation of odorous principles, eugenol, *p*-cresol, creosol, lactones (?) with lasting and fruity odour, benzaldehyde, jasmone, an unidentified ketone ($C_{12}H_{16}O_3$), benzoic acid, methyl anthranilate and indole. Analysis of Indian otto gave the following results: esters (as benzyl acetate), 74.8; alcohols (as benzyl alcohol), 15.46; methyl anthranilate, 0.45; indole, 1.75; and jasmone, 3.0% (Guenther, V, 334–36; Dhingra *et al.*, *Indian Soap J.*, 1950–51, **16**, 259).

Petroleum ether extracts (concrete) of flowers contain, besides the volatile oil, colouring matter and wax; the latter is an excellent fixative for perfumes and is recovered from concrete during the preparation of absolute. The wax possesses the following characteristics: sp. gr.$^{15°}$, 0.932; acid val., 5.4; ester val., 55.5; iod. val., 40.26; sap. val., 60.9; and m.p., 60°. It contains: hydrocarbons, 49.85; higher alcohols, 14.35; saturated acids, 21.31; and unsaturated acids, 14.50%. The wax retains small percentages of essence and can be used in the manufacture of soaps (Warth, 318; *Chem. Abstr.*, 1931, **25**, 5306).

*Uses*—Jasmine oil is used in high grade perfumes, ranking next only to rose in the order of importance. Almost all superior perfumes contain at least a small amount of jasmine oil. The absolute, although expensive, gives the best results; it blends with any floral scent imparting smoothness and elegance to perfume

TABLE 4—CHARACTERISTICS OF JASMINE CONCRETES, ABSOLUTES AND OILS FROM EUROPE*

| | Concrete of extraction | | Absolute of extraction | Steam-volatile oils | | |
|---|---|---|---|---|---|---|
| | | | | a | b | c |
| Sp. gr. | 0.886–0.8987 at 60°/60° | .. | 0.9290–0.9550 (at 20°) | 0.966–1.006 (at 20°) | 0.993–1.047 (at 15°) | 0.962 (at 15°) |
| [α]D | .. | +5 to +12 | +2.2° to +4.95° | −2.6° to +3.2 | +2.2° to +3.7° | +2.7° |
| n | 1.4640–1.4658 | .. | 1.4822–1.4935 (at 20°) | 1.4920–1.5041 (at 20°) | 1.4944–1.5015 (at 20°) | 1.4902 (at 20°) |
| Acid val. | 12.6–15.4 | 9.8–12.6 | 4.2–17.2 | 0.1–6.7 | 2.2–7.5 | 4.9 |
| Ester val. | .. | 68–105 | 96.4–147.6 | 165–227 | 234.0–268.8 | .. |
| Congealing pt. | .. | 47–51° | .. | .. | .. | .. |
| m.p. | 47–52° | 49–52° | .. | .. | .. | .. |
| Indole % | .. | .. | 0.08–0.20 | 0.10–0.31 | .. | .. |
| Methyl anthranilate % | .. | .. | 0.15–0.35 | 0.22–0.40 | .. | .. |

* Guenther, V, 327, 329–30, 333–34.
a Obtained from concrete. b From absolute of enfleurage. c From absolute of chassis.

compositions. Jasmine oil is used for perfuming expensive soaps and cosmetics, mouth washes and dentifrices, bath salts, sachets and tobacco. It is also used in incense and fumigants. Alcoholic washings of concrete are used in handkerchief perfumes (Guenther, V, 337–38; Poucher, II, 333, 375, 389; Jellinek, 111).

According to a recent estimate, the production of concrete jasmine in various countries amounts to 5,000 kg., of which nearly 50% is in Grasse (France). The possibility of manufacturing ottos and concretes in India has been recently investigated. Laboratory studies have established that the products obtained from Indian jasmines compare favourably with those produced in Grasse. Experimental trials have shown that the cost of production of jasmine absolute from *J. officinale* forma *grandiflorum* works out to Rs. 2,500–3,000 per lb., while that from *J. sambac*, to Rs. 1,500–2,000 per lb. It has been found that deodorised hydrogenated fat can be used in place of lard or other animal fat in the enfleurage process (Chatelain, *Perfum. essent. Oil Rec.*, 1951, **42,** 188; Dhingra *et al.*, *Indian Soap J.*, 1950–51, **16,** 235; *Perfum. essent. Oil Rec.*, 1953, **44,** 11).

**J. ritchiei** C.B. Clarke

Fl. Br. Ind., III, 598; Talbot, II, Fig. 386.

TAM. *Karumullai*; TEL.—*Adivimalle*.

A climbing or scandent shrub commonly found in the rain forests of Konkan, N. Kanara and western ghats of Mysore and Nilgiris and in middle Andaman Islands. Leaves ovate, acuminate, glabrous; flowers white, borne in 3–9 flowered, lax, often sub-paniculate cymes.

The leaves are reported to be useful in toothache; the wood is used for pipe tubes. The flowers are used in an oily preparation for piles (Kirt. & Basu, II, 1525; Rama Rao, 247).

**J. rottlerianum** Wall. ex DC.

Fl. Br. Ind., III, 593.

SANS.—*Vanamalliga* TAM.—*Kattumalligei, erumaimullai*; KAN.—*Vanamallige*; MAL.—*Vellakattumulla*.

A large scandent, villous shrub commonly found in western ghats up to 5,000 ft. from Konkan southwards to Kerala. Leaves elliptic, often sub-cordate at the base, acute or acuminate, softly hairy on both surfaces, or glabrous above; flowers white, in terminal cymes; corolla lobes 5–7, oblong, obtuse; carpels ellipsoid, smooth and black. The plant flowers in January–March and fruits during June–August.

The leaves are reported to be employed in preparations for eczema in children and for purifying blood; the flowers, which are not fragrant, are similarly used (Chopra, 500; Kirt. & Basu, II, 1526; Rama Rao, 245).

**J. sambac** (Linn.) Ait. ARABIAN JASMINE, TUSCAN JASMINE

D.E.P., IV, 544; Fl. Br. Ind., III, 591 Bor & Raizada, 218.

SANS.—*Mallika*; HINDI—*Banmallika, chamba, moghra*; BENG.—*Motia, mogra*; MAR.—*Mogra, bat-mogri*; TEL.—*Boddumalle, gundumalle, manmathabanmu*; TAM. *Adukkumalli, gundumalli, virupakschi, kuda-malligai*; KAN.—*Elusuttu mallige, iruvantige, sujimallige, kolumallige*; MAL.—*Cherupichakam, kudamulla, nallamulla*.

A scandent or sub-erect shrub found throughout India, mostly under cultivation. Branchlets pubescent; leaves opposite or sometimes ternate, variable in shape, usually ovate or elliptic, glabrous or nearly so, with prominent lateral nerves; flowers white, very fragrant, solitary, or in 3-flowered terminal cymes; calyx teeth 5–9, linear-subulate; corolla lobes

FIG. 152. JASMINUM SAMBAC—FLOWERING BRANCH

narrowly oblong, acute or obtuse, orbicular in cultivation : carpels black when ripe.

This plant is much valued for its exquisitely fragrant flowers and is cultivated nearly throughout the tropical and sub-tropical parts of the world. While its cultivation in India dates back to ancient times, its original home is considered to be some region west of India. It is very variable and includes a large number of horticultural forms. The Indian types can be classified under 4 distinct groups: (1) *Motiya bela* (TAM.—*Virupakshi ;* KAN. *Iruvantige*) with double flowers, rounded petals and globular buds : (2) *Bela* (TAM.—*Gundumalli*) also double flowered with elongated petals : (3) *Hazara bela* (KAN.—*Sujimallige*) with single flowers : and (4) *Mungra* (TAM.—*Adukkumalli ;* KAN.—*Elusuttumallige*) with multi-whorled petals which are rounded and the buds measuring about one inch in diameter (Burkill, II, 1264 : Krishnaswamy & Raman, *J. Indian bot. Soc.*, 1948, **27,** 77 : Bhatnagar, *Sci. & Cult.*, 1955-56, **21,** 613).

The plant is propagated by cuttings in the same way as *J. officinale* forma *grandiflorum*. It prefers dry locations and flowers most profusely when grown under direct exposure to sun. Its culture is similar to other jasmines. It flowers during hot and rainy seasons and stripping off the leaves before flowering induces profuse blossoms.

The double flowered forms are the most popular. They are cultivated on a commercial scale in parts of U.P. (Kanauj, Jaunpur, Ghazipur and Sikandarpur) and Madras. The average yield of flowers per acre is 600 kg. (3,000–4,000 flowers per kg.) with a maximum yield of 1,000 kg. The acreage under this jasmine in U.P. is given in Table 1 (Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1953, **44,** 11).

*J. sambac* is often attacked by scale insects, resulting in black fungal growths on leaves. The larvae of jasmine fly, a cecidomyiid, cause considerable damage to buds. Spraying with Parathion (0.025%) with Sandovit as adhesive checks the pest to a considerable extent (Bor & Raizada, 218 : Rao *et al.*, *Andhra agric. J.*, 1954, **1,** 313).

The flowers of *J. sambac* are widely used in India for making garlands and bouquets and for religious offerings. It is used in China for flavouring tea. About 30 lb. of the flowers are mixed with 10 lb. of *J. paniculatum* flowers to flavour 100 lb. of tea. In Malaya, the flowers are used in scenting coconut hair oil (Burkill, II, 1204 ; Encyclopaedia Britannica, 1938, XII, 969).

The flowers of *J. sambac* are used in the same way as those of *J. officinale* forma *grandiflorum* for the extraction of perfume. It is estimated that nearly 400 md. of flowers are annually used for the extraction of perfumed oil and 250 md. for the preparation of attar. Extraction of flowers with petroleum ether yields 0.43% concrete, which gives 26.39% absolute. The absolute is deep red in colour and possesses an odour suggestive of jasmine and orange flower, being extremely warm, strong and powerful. A sample of absolute from East Africa, prepared by the enfleurage process, had the following characteristics: $d^{15^\circ}$, 1.024 ; $[\alpha]_D^{20^\circ}$, +2.41° ; $n_D^{20^\circ}$, 1.5061 ; and sap. val., 153.3. The properties of concrete (benzene extraction) and otto (direct distillation) from Indian flowers are given in Table 2 ; yields of otto obtained by different methods are given in Table 3. The otto possesses a very pleasing and lasting note and can be employed in the preparation of high class perfumes, cosmetics and toilet soaps. It contains: esters (as benzyl acetate), 32.45–35.20 ; alcohols (as linalool), 30.73–35.58 ; methyl anthranilate, 2.88–3.51 : and indole, 2.75–2.82% (Naves & Mazuyer, 196, 201 : Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1953, **44,** 11).

The flowers contain a yellow pigment, used as a substitute for saffron (Wehmer, II, 957).

The flowers and other parts of the plant are used in medicine. Flowers are used in Malaya in applications for congestive headache. A lotion made of the flowers is used for washing the face and eyes. Crushed flowers are sometimes used as a lactifuge. A decoction of the leaves is used for fevers. Leaves are applied as a poultice for skin complaints and ulcers. Roots are used with leaves in eye lotions (Burkill, II, 1266 ; Kirt. & Basu, II, 1516).

**J. scandens** Vahl

Fl. Br. Ind., III, 595.

NEPAL—*Hare lahara.*

A scandent shrub with pubescent branchlets found in the lower hills of Sikkim, Bengal and Assam and further south in Bihar, Orissa and N. Circars. Leaves ovate-lanceolate, acuminate, with rounded base ; cymes dense, often on short axillary branches ; flowers white, tinged with pink, very fragrant ; corolla tube short : lobes oblong, acute : carpels ellipsoid. The plant bears flowers in November-February ; fruits appear during early summer.

The root of the plant is reported to be useful in the treatment of ringworm. The leaves contain a bitter substance, jasmiglabrin, and an inactive alkaloid

**TABLE 5—DISTRIBUTION OF SOME JASMINUM SPECIES IN INDIA AND THEIR ORNAMENTAL VALUE**

| Species | Distribution | Flowering period | Flower colour and odour | Remarks |
|---|---|---|---|---|
| *J. amplexicaule* Buch.-Ham. ex G. Don syn. *J. undulatum* Ker-Gawl., non Willd. | Sikkim, Bhutan, Assam, Khasi hills up to 5,000 ft. | Sept.-Nov. | White, fragrant[1] | |
| *J. attenuatum* Roxb. ex G. Don | Assam, Khasi & Lushai hills | Mar. Apr. | Bright red, pink or white[3] | |
| *J. azoricum* Linn. | .. | Febr. | White, scentless | Cultivated for its profuse flowers[8] |
| *J. brevilobum* A. DC. | Western ghats, Nilgiris & Pulneys, above 3,000 ft. | June Sept. | White, very fragrant[7] | |
| *J. calophyllum* Wall. ex DC. | Baroda, south Deccan, western ghats, Nilgiris, Anamalais, hills of Tinnevelly, up to 4,000 ft. | | White, fragrant | Cultivated[6,10] |
| *J. coarctatum* Roxb. | Assam, Khasi & Lushai hills, up to 4,000 ft. | Apr. June | White, fragrant[2,3] | |
| *J. dispermum* Wall. | Sub-Himalayan tract from Kashmir to Bhutan up to 8,000 ft. and Khasi & Jaintia hills | Apr. May | White or tinged with pink, fragrant[1] | |
| *J. diversifolium* Kobuski syn. *J. heterophyllum* Roxb., non Moench | Nepal, N. Bengal, Assam hills, Khasi hills and Manipur | Apr. May | Yellow, delightfully fragrant[1,3,5] | Cultivated |
| *J. dumicolum* W. W. Smith | Naga hills & Manipur | | White inside, deep rose or crimson outside & fragrant[1,3] | |
| *J. fruticans* Linn. | | | Bright yellow, scentles | Cultivated ; roots used as adulterant of *Gelsemium* ; flowers contain mannose, jasminine & syringine[11,14] |
| *J. glandulosum* Wall. ex. G. Don | N. W. Himalayas, Nepal, Sikkim, Khasi, Aka & Lushai hills | July Aug. | White, fragrant[2] | |
| *J. lanceolarium* Roxb. syn. *J. paniculatum* Roxb. | Aka, Naga, Khasi & Jaintia hills, up to 5,000 ft. | Apr.-May | White, very fragrant | Cultivated : flowers used for scenting tea in China[1,12,13,15] |
| *J. laurifolium* Roxb. | Assam, Aka, Khasi & Lushai hills | Mar. May | Buds red, corolla partially red, faintly fragrant[2,3] | Cultivated[8] |
| *J. nervosum* Lour. syn. *J. anastomosans* Wall. ex DC. | Bhutan, N. Bengal, Assam, Khasi & Lushai hills | Jan. Apr. | White, fragrant[1,2] | |
| *J. rigidum* Zenker, non Thw. | Deccan & Carnatic, plains & hills up to 6,000 ft. in western ghats | Mar.-Apr. | White, very fragrant[7] | Cultivated : resembles *Carissa paucinervia* DC. |
| *J. strictum* Haines | Endemic to Chota Nagpur | May June | Sweet scented[4,5] | |
| *J. subtriplinerve* Blume | N. Bengal, Assam & Khasi hills up to 5,500 ft. | Apr. May | White, fragrant[1] | |
| *J. syringaefolium* Wall. ex G. Don | Assam | Dec. Apr. | Faintly fragrant | Cultivated[8,9] |

[1] Kobuski, *J. Arnold Arbor* 1932 **13,** 145 ; 1939, **20,** 403. [2] Fischer, *Rec. bot. Surv. India*, 1938, **12**(2), 110. [3] Fl. Assam, III, 225-34. [4] Haines, IV, 525. [5] Mooney, 85. [6] Cooke, II, 115. [7] Fyson, I, 387. [8] Firminger, 460 63. [9] Burns & Davis, 61. [10] Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 99. [11] Wehmer, II, 957. [12] Finnemore, 689. [13] Parry, I, 277. [14] Youngken, 659. [15] Encyclopaedia Britannica, 1938, XII, 969.

(Kirt. & Basu, II, 1524 : Firminger, 463 ; Wehmer, II, 957).

*J. nudiflorum* Lindl., a trailing deciduous shrub, native of China, is reported to have been tried in Indian gardens, but without much success. It bears opposite trifoliolate leaves and solitary yellow flowers. The plant is considered to be diaphoretic. Leaves and twigs contain tannin (0.47 and 1.80% respectively) ; the twigs contain also a glucoside, syringin, jasmiflorine, mannose and a bitter substance, jasmipicrine (Bailey, 1947, II, 1718 : Firminger, 462 : Roi, 404 : *Chem. Abstr.*, 1942, **36**, 2438 : Wehmer, II, 957).

*J. odoratissimum* Linn., an erect glabrous shrub native of Madeira and Canary Islands, with stiff, terete or slightly angular branches and yellow, fragrant flowers is grown in some gardens in India. The plant is cultivated in Formosa for the flowers which are reported to be used for flavouring tea. The flowers retain, even when dry, their natural perfume which combines the fragrance of jasmine, jonquil and orange blossoms. They yield on extraction a reddish brown absolute (0.116%) with the following constants: $d^{15^\circ}$, 0.9309 : $[\alpha]_D^{15^\circ}$, +5.64° : $n_D^{15^\circ}$, 1.4845 : acid val., 5.85 : sap. val., 92.25 : and ester val. after acetylation, 186.20. The absolute contains linalool, *d*-linalyl acetate, benzyl alcohol, benzyl acetate, methyl anthranilate, indole and a sesquiterpene or diterpene alcohol : jasmone is absent (Cooke, II, 114 : Naves & Mazuyer, 199–200 : Poucher, II, 142 : Parry, I, 276).

Besides the species dealt with, a large number of species occur wild or are grown in gardens for their fragrant, white or yellow flowers. Many of them have been recorded from the sub-Himalayan tract extending from Kumaon to Assam. Available information regarding their distribution in India is summarised in Table 5.

**Jasper** — *see* **Quartz**

## JATEORHIZA Miers (*Menispermaceae*)

A small genus of scandent herbs or undershrubs distributed in tropical Africa. *J. palmata*, the source of the drug CALUMBA, is reported to be cultivated in India : however, authentic information on its cultivation and on the use of the drug in Indian medicine is lacking.

**J. palmata** (Lam.) Miers syn. *J. calumba* Miers ; *Cocculus palmatus* DC.

Kirt. & Basu, I, 98 ; Bentley & Trimen, I, Pl. 13.

HINDI—*Kalamb-ki-jar* ; TEL.—*Kalamba-veru* ; TAM.—*Kalamba ver* ; ORIYA—*Kolombo*.

BOMBAY—*Colombo, kalamb-kachari.*

A lofty dioecious twiner, indigenous to Mozambique in south-east tropical Africa. Rhizome short, rounded, irregular, giving off clusters of fusiform, succulent roots, up to 4 in. diam. ; leaves alternate, palmately 3–7 lobed, up to 14 in. × 10 in., deeply cordate at the base : petioles long ; flowers inconspicuous, in large drooping, axillary panicles ; fruit a fleshy drupe, ovoid.

The roots constitute the drug Calumba, Columba or Columbo, which is reported to be imported into India from Africa and also re-exported to Europe and America. In its native country, the roots and the rhizomes of the plant are dug out during dry weather ; the rhizomes are rejected and the roots cut transversely or obliquely into slices and dried in the shade. The slices, which are brownish owing to adhering earth, constitute Natural Calumba, in which form it is usually exported. After washing and brushing, the drug is graded and marketed as Washed Calumba (U.S.D., 1947, 203–04).

The commercial drug consists of yellowish, irregularly circular, oval or obliquely cut pieces of roots, up to 4 inches in diam. and 0.15–0.7 inch in thickness. They are depressed in the centre and covered with greyish brown longitudinally wrinkled bark. Compact, uniform and brightly coloured pieces, not damaged by worms, are preferred. The drug has a short mealy fracture, slight musty odour and a very bitter taste. The drug is often admixed with sliced rhizomes of the plant. It is adulterated with and sometimes substituted by pieces of the stems of *Coscinium fenestratum* Colebr., CEYLON CALUMBA or FALSE CALUMBA. According to the specifications, the drug should not contain more than 2% foreign organic matter, 9% ash and 2% acid-insoluble ash : it should yield not less than 12 per cent of alcohol (60%) soluble extractive. It should be stored in a dry place (B.P.C., 1949, 192–93 : Trease, 283 : U.S.D., 1947, 203).

The activity of the drug is attributed to the presence of alkaloidal and non-alkaloidal bitter principles. Three water-soluble quaternary alkaloids, namely palmatine, jatrorrhizine (jateorhizine) and columbamine, all related to berberine, are reported to be present in the drug : the first two have been isolated in the form of their iodides (palmatine iodide : $C_{21}H_{22}O_4NI.2H_2O$ ; m.p., 241° decomp. ; jatrorrhizine iodide : $C_{20}H_{20}O_4NI.H_2O$ ; m.p.,

210–12°) and columbamine, in the form *dl*-tetrahydro-columbamine ($C_{20}H_{23}O_4N$ ; m.p., 223–24°). The yield of alkaloids, in the form of crude iodides, is *c.* 4.3% of which 2% is palmatine iodide. On *o*-methylation, jatrorrhizine iodide yields palmatine iodide; methylation of tetrahydro-columbamine yields tetrahydropalmatine (Thorpe, II, 235 ; Henry, 342).

The alkaloids paralyse the central nervous system in frogs ; palmatine is effective in mammals also and excels morphine in respiratory toxicity. Columbamine and jatrorrhizine increase intestinal tonus. The alkaloids lower the blood pressure when given intravenously, palmatine being the most active (Henry, 345 ; U.S.D., 1947, 204).

The non-alkaloidal bitter principles reported to be present in the drug are columbin [$C_{20}H_{22}O_6$ : m.p., 192–95° (decomp.)], palmarin ($C_{20}H_{22}O_7$ : m.p., 256–60°) and chasmanthin ($C_{20}H_{22}O_7$ : m.p., 246°). Columbin which is the major component is intensely bitter and causes vomiting and diarrhoea. It is diterpenoid lactone ; zinc dust distillation gives 1,2, 5-trimethyl-naphthalene. Besides the bitter principles, the root contains starch (30%), mucilage, salts of calcium and potassium, and silica. On distillation it yields 0.07–1.15% of a greenish volatile oil (b.p., 165 68° ; $d^{25°}$, 0.9558 ; $n_D^{25°}$, 1.4755) containing thymol as one of the principal constituents. The oil has the odour of fresh hay. Old roots are poor in oil (Allen, VII, 303 ; Cava & Soboczenski, *J. Amer. chem. Soc.*, 1956, **78,** 5317 ; U.S.D., 1947, 204 ; *Chem. Abstr.*, 1936, **30,** 5998 ; 1935, **29,** 4366 ; 1932, **26,** 1389).

Calumba is a bitter tonic and stomachic ; it is useful, especially with other tonics, cathartics and aromatics, in atonic dyspepsia, gastric irritability, diarrhoea, dysentery and vomiting attending on pregnancy. It is usually prescribed in the form of an infusion or tincture. It is free from tannic or gallic acid and is compatible with alkalies and iron salts. Powdered calumba has been employed in dressing sores (U.S.D., 1947, 204 ; Bentley & Trimen, I, 13 ; B.P.C., 1949, 193 ; Dymock, Warden & Hooper, I, 48).

**Jat Fibre** — *see* **Corchorus**

**Jat, Tossa** — *see* **Corchorus**

**Jat, White** — *see* **Corchorus**

## JATROPHA Linn. (*Euphorbiaceae*)

A large genus of herbs, shrubs and trees distributed in the tropical and sub-tropical parts of the world, chiefly in Africa and America. About 9 species have been recorded in India ; some of them are grown in gardens for their ornamental foliage and flowers.

**J. curcas** Linn. PHYSIC NUT, PURGING NUT

D. E. P., IV, 545 ; C.P., 699 ; Fl. Br. Ind., V, 383 ; Kirt. & Basu, Pl. 867B.

SANS.—*Kananaeranda, parvataranda* ; HINDI—*Bagbherenda, jangliarandi, safedarand* ; BENG.—*Bagbherenda, erandagachh* ; MAR.—*Mogalierenda, ranayerandi* ; GUJ.—*Jamalgota, ratanjota* ; TEL.—*Nepalamu, peddanepalamu, adaviamidamu* ; TAM.—*Kadalamanakku, kattamanakku* ; KAN.—*Adaluharalu, bettadaharalu, maraharalu, karnocchi* ; MAL.*Kattavanakka, kadalavanakka.*

ORISSA—*Jahazigaba* ; ASSAM—*Bongalibhotora* ; GARO HILLS—*Borbandong.*

A large shrub, 3–4 m. high, native of tropical America, occurring almost throughout India and in Andaman Islands. Leaves alternate, 10–15 cm. × 7.5–12.5 cm., broadly ovate, cordate, acute, usually palmately 3 or 5-lobed, glabrous ; flowers in loose panicles of cymes, yellowish green, *c.* 7 mm. across ; fruits *c.* 2.5 cm. long, ovoid, black, breaking into three 2-valved cocci ; seeds ovoid-oblong, dull brownish black.

The plant is reported to have been introduced into Asia and Africa by the Portuguese as an oil-yielding plant. It is cultivated to a certain extent as an oil-seed crop in Cape Verde Islands : a yield of 350–1,000 lb. of seeds per acre has been reported. In Madagascar and parts of French West Africa, where the plant is grown as a support for the vanilla plant, the seeds are collected and exported to France for the extraction of oil (Burkill, II, 1268 ; Juillet *et al.*, 354).

*J. curcas* is found in India in a semi-wild condition in the vicinity of villages. It is propagated easily by seeds or cuttings ; it grows rapidly, is hardy to dry weather conditions and is not browsed by goats or cattle ; it can be cut or lopped at any desired height and is well adapted for hedges. It flowers in hot and rainy seasons, and sets fruit in winter when it is leafless [Burkill, II, 1268 ; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 100 ; Nicholls & Holland, 580 ; *Farmer*, 1955, **6**(12), 8 ; Benthall, 373].

The seed resembles castorseed in shape, but is smaller in size (wt., 0.5–0.7 g. ; length, 1–2 cm.) and of dark brown colour. Analysis of the seed gave the following values : moisture, 6.62 ; protein, 18.2 ; fat, 38.0 ; carbohydrates, 17.98 ; fibre, 15.50 ; and ash,

4.50% : starch, sucrose, dextrose, gluten, a free acid and an active lipase are present (Williams, K.A., 336 : U.S.D., 1955, 1593 : *Chem. Abstr.*, 1953, **47,** 10174 : Wehmer, II, 688).

The seeds possess poisonous and purgative properties : they are rarely used as purgative. Three to five seeds, slightly roasted and decorticated, are sufficient for active catharsis ; they seldom produce nausea and vomiting, but cause a sense of burning in the stomach. They contain two toxic principles, curcine or curcasin, a toxalbumin resembling ricine, and a resinous substance (possibly resinolipoid) with nauseating and purgative action : electron microscope studies suggest that curcine consists of two components. The seeds are considered anthelmintic in Brazil. They are ground with palm oil and used as rat poison in Gabon. In Travancore, the seeds are fried, powdered and taken with molasses for stomach ache and as antidote for poisoning (U.S.D., 1955, 1593 ; Tschirch & Stock, II, 1774 ; Tumminkati *et al.*, *J. Univ. Bombay*, 1945, **14A,** 34 : *Chem. Abstr.*, 1957, **51,** 16632 : Caius, *J. Bombay nat. Hist. Soc.*, 1938 39, **40,** 294 : Dalziel, 148 : Rama Rao, 364).

The kernel forms 60–68% of the weight of seed and yields an oil (46–58% of kernel wt. ; 30–40% of seed wt.) which when fresh is practically colourless and odourless ; on standing the oil acquires a pale yellow or yellowish brown colour and a disagreeable odour. The oil is obtained from decorticated seeds by expression or solvent extraction and is known in the trade as Curcas Oil. It has the following range of constants: sp. gr.$_{15^\circ}^{15^\circ}$, 0.918–0.923 ; $n_D^{40^\circ}$, 1.462–1.465 ; acid val., 1–20 ; sap. val., 188–196 ; iod. val., 93–107 ; hydroxyl val., 4–20 ; R. M. val., 0.2–1.1 ; Polenske val., 0.4–0.9 ; $\eta^{20^\circ}$, 7.1 centipoises ; and unsapon. matter, 0.4–1.1%. The fatty acid composition of the oil is as follows: myristic, 0–0.5 ; palmitic, 12–17 ; stearic, 5–6 ; arachidic, 0–0.3 ; oleic, 37–63 ; and linoleic acid, 19–40%. The values reported for oil extracted from Malabar seeds are as follows : $d^{30^\circ}$, 0.9849 ; $n_D$, 1.4669 : acid val., 26.27 ; sap. val., 196.1 ; iod. val., 90.84 ; and unsapon. matter, 0.2%. The fatty acid composition is as follows: myristic, 1.37 ; palmitic, 15.61 ; stearic, 9.69 ; arachidic, 0.35 ; oleic, 40.9 ; and linoleic, 32.08% (Thorpe, III, 460 ; Eckey, 583 ; Kartha & Menon, *Proc. Indian Acad. Sci.*, 1943, **18A,** 160).

Curcas oil (purging dose, 0.3–0.6 cc. or 5–10 minims) differs from castor oil in that it has a low viscosity, is slightly soluble in alcohol but freely miscible with light petroleum, and is optically inactive. The poisonous principle appears to exist in the alcohol-soluble fraction, which on saponification yields fatty acids, a phytosterol and a resin, devoid of any toxicity when examined separately (U.S.D., 1955, 1593 ; Thorpe, III, 460 ; Tschirch & Stock, II, 1773).

The oil is semi-drying and may be employed for the preparation of non- or semi-drying alkyds. In China, a varnish is prepared by boiling the oil with iron oxide. The oil is used as an illuminant ; it burns without emitting smoke. It can be used also as a lubricant and for making soaps and candles. It is used in wool-spinning in England. In Senegal, it is said to have been used as an adulterant of groundnut oil. It is used as an external application for skin diseases and rheumatism ; it is reported to be abortifacient and also efficacious in dropsy, sciatica and paralysis. In Java, the oil is applied to hair as growth stimulant. It is also used as an application for sores on domestic stock (Chatfield, 87 ; Burkill, II, 1269 ; Dalziel, 147 ; Quisumbing, 516 ; Caius, loc. cit.).

The seed cake contains toxic principles and is unfit for use as cattle feed. It is rich in nitrogen and phosphorus (N, 3.2 ; $P_2O_5$, 1.4 ; and $K_2O$, 1.2%) and can be used as manure. The cake protein may be employed as a raw material for plastics and synthetic fibres (Eckey, 584 ; *Bull. imp. Inst., Lond.*, 1921, **19,** 288 ; Vyas & Desai, *J. Indian chem. Soc. industr. Edn*, 1952, **15,** 68).

All parts of the plant exude a sticky, opalescent, acrid and astringent latex, containing resinous substances (14.6% in the latex coagulum) but no rubber. The latex dries to a bright reddish brown, brittle substance, resembling shellac ; it stains linen indelibly and can be used as marking ink. The bark contains tannin (37%, dry basis) ; it also contains wax, resin, saponins, reducing sugars and traces of a volatile oil. The wax consists of a mixture of melissyl alcohol and melissyl melissate. The bark yields a dark blue dye reported to be used in the Philippines for colouring cloth, fishing nets and lines. A dye may be extracted also from the leaves and tender stems, and concentrated to a yellowish syrup or dried to a blackish brown lumpy mass ; the dye imparts to cotton different shades of tan and brown which are fairly fast (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 56 ; Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 11 ; Dalziel, 147 ; Howes, 1953, 280 ; Quisumbing, 513 ; Villadolid & Sulit, *Philipp. Agric.*, 1932–33, **21,** 33 ; Alde *et al.*, *Philipp. J. Sci.*, 1947, **77,** 55).

Tender twigs of the plant are used for cleaning teeth ; the juice is reported to relieve toothache and

strengthen gums. Young branches and leaves are used as manure for coconut trees. In Java and Malaya, tender leaves are reported to be eaten after cooking. In Assam, leaves are used as feed for the eri silk worm (Burkill, II, 1270).

The juice of the plant is used as a purgative and haemostatic in Java; it is used for stupefying fish in the Philippines. The leaves are considered rubefacient and lactagogue: they are also reported to have insecticidal properties. In Ghana, the leaves are used for fumigating houses against bed-bugs. The leaf juice is used as an external application for piles: it is applied for inflammations of the tongue in babies. The twig sap is considered styptic and used for dressing wounds and ulcers; an emulsion of the sap with benzyl benzoate is said to be effective against scabies, wet eczema and dermatitis. A decoction of leaves and roots is given for diarrhoea. The root is reported to contain a yellow oil with strong anthelmintic action. The root bark is used in external applications for sores. In Konkan, the bark is rubbed with asafoetida and buttermilk and the paste given in cases of dyspepsia and diarrhoea. A decoction of the bark is given for rheumatism and leprosy (*Chem. Abstr.*, 1941, **35,** 6854; Burkill, II, 1269–70; Kirt. & Basu, III, 2245; Caius, loc. cit.; Rama Rao, 364; Brown, 1941, II, 1270; Neal, 449; Dalziel, 147-48; Fox, *Philippine J. Sci.*, 1952, **81,** 210; Quisumbing, 515; Vyas & Desai, loc. cit.; *Chem. Abstr.*, 1930, **24,** 684).

**J. glandulifera** Roxb.

D.E.P., IV, 548; C.P., 700; Fl. Br. Ind., V, 382; Kirt. & Basu, Pl. 866A.

Hindi—*Janglierandi, undarbibi*; Mar.—*Janglierandi*; Tel.—*Dundigapu*; Tam.—*Adalai, eliyamanakku, puliyamanakku*; Kan.—*Totlagida*; Mal.—*Atala, nakadanti.*

An evergreen shrub with stout branches and a smooth papery bark, found in the black cotton soils of Deccan and Carnatic, from Krishna river southwards, particularly near the sea coast. Leaves simple, glabrous, 6.3–12.5 cm. long and equally broad, palmately 3–5 lobed below the middle: lobes obovate or elliptic, acuminate, margin serrate; flowers greenish yellow, in glandular corymbose cymes; capsules up to 1.3 cm. long, ellipsoid-oblong, slightly 3 lobed; seeds ellipsoid-oblong, c. 8 mm. long, smooth, shining and black.

This plant is much restricted in distribution and is often confused with *J. gossypifolia*, which is a more common plant; it is distinguished from the latter by the serrate gland-tipped leaves, long branched gland-tipped stipules and greenish yellow flowers (Tadulingam & Venkatanarayana, 304; Cooke, II, 597).

The seeds contain a fixed oil (20–22%), tannin, glucose, polysachharides and a resinous substance. The oil is brownish yellow in colour and has the following constants: sp. gr.$^{29°}$, 0.9066; $n_D^{30°}$, 1.477; sap. val., 195.2; acet. val., 16.8; iod. val. (Wijs), 117.8; acid val. (as oleic acid), 5.6; R. M. val., 1.65; Polenske val., 0.88; and unsapon. matter, 1.75%. Sitosterol is present in the unsaponifiable fraction. The fatty acids present are: myristic, 2.34; palmitic, 14.5; stearic, 5.97; oleic, 34.19; and linoleic, 43.0% (Alimchandani *et al.*, *J. Indian chem. Soc.*, 1949, **26,** 523; Sheth & Desai, ibid., 1954, **31,** 407).

The oil possesses purgative properties, but is seldom used as a purgative. It is applied externally in rheumatism and paralytic affections. In combination with castor or coconut oil, it may be used for cold saponification; the mixed oil soap obtained possesses good lathering properties. The protein extracted from the oilcake may be utilised as a raw material for plastics and synthetic fibres (Sheth & Desai, *J. Indian chem. Soc. industr. Edn*, 1954, **17,** 197).

The bark contains glucose, myricyl alcohol and an oil containing myristic, stearic and probably petroselenic acid; a crystalline substance (m.p., 83–86°) has been isolated. Aqueous extracts of the fresh bark sap possess emulsifying and gel-forming properties: the gel obtained with benzyl benzoate may be used as an application for skin diseases. The root is pounded with water and given to children suffering from abdominal enlargements: it causes purging and reduces glandular swellings (Sheth & Desai, *Sci. & Cult.*, 1954–55, **20,** 243; *J. Indian chem. Soc. industr. Edn*, 1954, **17,** 197).

**J. gossypifolia** Linn.

Fl. Br. Ind., V, 383; Bor & Raizada, 175.

Hindi—*Bherenda, verenda*; Beng.—*Lalbherenda*; Tel.—*Nela-amida*; Tam.—*Atalai.*

Assam—*Bhotera.*

A bushy gregarious shrub, 0.9–1.8 m. in height, native of Brazil, but naturalised almost throughout India. Leaves palmately 3–5 lobed, c. 20 cm. long and equally wide, at first brown, shining, later turning green: margins of leaves, petiole and leaf blade covered with glandular hairs; flowers dark red, crimson or purplish, in glandular corymbose cymes; capsules, c. 9 mm. long, 3-lobed, truncate at both ends; seeds greyish red with a caruncle.

FIG. 153. JATROPHA GOSSYPIFOLIA—FLOWERING BRANCH

*J. gossypifolia* is cultivated in gardens for ornament; it occurs gregariously as an escape in waste areas. The plant is easily raised from seeds; it flowers and fruits during the rainy season (Talbot, II, 468; Fl. Madras, 1340; Haines, II, 101; Bor & Raizada, 176).

The dried stem bark of the plant contains an intensely bitter amorphous alkaloid, jatrophine ($C_{11}H_{20}O_6N$: yield, 0.4%), which is similar to quinine in properties; the toxic dose for guinea pigs, when injected sub-cutaneously, is 0.2 g./kg. body weight. The bark contains also resins, isophytosterol (0.35%) and tannin. The latex (total solids, 13.38%) is poisonous and contains 2.5% alcohol-soluble matter (Villalba, *J. Soc. chem. Ind., Lond.*, 1927, **46**, 396 T; Wehmer, II, 689; Viswa Nath, *J. sci. industr. Res.*, 1942–43, **1**, 374; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 56).

The ether extract of the shoots shows antibiotic activity against *Staphylococcus aureus* and *Escherichia coli*. Aqueous extract of the plant possesses insecticidal properties. Tender leaves contain a pentose glycoside of cyanidin (Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261; *Chem. Abstr.*, 1950, **44**, 783; Ponniah & Seshadri, *J. sci. industr. Res.*, 1953, **12B**, 608).

The roots are employed in Venezuela against leprosy; they are also reported to be used as an antidote for snake bite. The plant is used by Mundas in urinary complaints. A decoction of the bark is used as an emmenagogue; that of the leaves for stomach ache, venereal diseases and as blood purifier. The leaves are also applied to carbuncles, eczema and itches. The leaf juice is applied for sores on the tongues of babies, and a cataplasm of fresh leaves is applied to swollen mammae. They are used as a febrifuge in intermittent fevers in Antilles. The latex is applied to ulcers. The seeds are eaten by doves and fowls. The seed oil is used in lamps and also for leprosy (Quisumbing, 517; Bor & Raizada, 176; Bressers, 19; Kirt. & Basu, III, 2247; Dalziel, 148; Burkill, II, 1271).

**J. multifida** Linn. CORAL PLANT

Fl. Br. Ind., V, 383.

SANS.—*Bhadradanti, brihaddanti, jyotishka, virechani*; MAR.—*Chiniyerandi*; TAM.—*Kattuneruvalam, malaiyamanakku*; KAN.—*Vilayatiharalu*.

A large shrub or small tree, 2–3 m. high, naturalised in various parts of India. Leaves long-petiolate, 7.5–12.5 cm. diam., palmately divided into 5–11 lobes: lobes lanceolate-acute or elliptic-acute; flowers coral-red, borne on many flowered, long-pedunculate, flat-topped, terminal cymes; capsules 3-lobed, c. 2.5 cm. long, obovate, smooth, yellowish.

The plant is a native of S. America and is widely grown for its ornamental foliage and flowers. It is easily propagated by seeds or cuttings; flowers and fruits appear mainly during the rainy season (Bor & Raizada, 177; Gopalaswamiengar, 276).

The plant is grown in hedges in Java and the Philippines. The tuberous roots are eaten after roasting. In Indo-China, a decoction of dried roots is given for indigestion and colic, and also as a tonic. The fruit is poisonous and causes vomiting and intense burning pain in the stomach; lime juice and stimulants are administered as antidotes in cases of poisoning. The seeds possess properties akin to those of *J. curcas* and contain a bitter principle (c. 1%) soluble in water and ether. They contain a fixed oil (c. 30%) used as an illuminant. The leaves are said to be cooked as vegetable in Mexico. Tender leaves are eaten in Costa Rica. The leaves are used also for scabies and as purgative. The latex of the plant is applied to wounds and ulcers. The whole plant is used as fish poison in the Philippines (Burkill, II, 1271; Nadkarni, I, 708; Modi, 561; Quisumbing, 518; Dalziel, 148; Brown, 1941, II, 316; Bor & Raizada, 177; Kirt. & Basu, III, 2243).

The leaves of the plant contain a saponin, a resin and tannin. Saline and ether extracts of the shoots

FIG. 154. JATROPHA MULTIFIDA—FLOWERING BRANCH

show antibiotic activity against *Escherichia coli*. The latex from the trunk contains a yellow-green volatile oil (*c.* 0.3%; $d^{20°}$, 0.8885) with an onion-odour and a taste, first cooling and then nauseating; its predominant constituents are sesquiterpenes, a free acid (angelic acid) and probably benzyl mustard oil. The oil possesses the property of disintegrating lepromae (Wehmer, II, 687; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B,** 261; *Chem. Abstr.*, 1935, **29,** 7016).

**J. nana** Dalz. & Gibs.

D.E.P., IV, 549; Fl. Br. Ind., V, 382; Kirt. & Basu, Pl. 867A.

MAR.—*Kirkundi.*

A small, sparingly branched shrub, 30–45 cm. high found in stony and waste places near Poona and Bombay, being apparently endemic to the Deccan. Leaves entire or 3-lobed, 7.5–12.5 cm. long and about equally broad; flowers pedicellate, in few-flowered terminal paniculate cymes; capsules *c.* 1 cm. long, obovoid-oblong, 3-lobed, flattened at the top. The plant flowers from May to July. The juice of the plant is said to be employed as a counter-irritant in ophthalmia.

*J. panduraefolia* Andr. (FIDDLE-LEAVED JATROPHA) and *J. podagrica* Hook. (GUATEMALA RHUBARB, GOUTY-STEMMED JATROPHA) are both natives of America. They are widely grown in Indian gardens for ornament. They are propagated by seeds (Bor & Raizada, 173-75; Firminger, 375; Gopalaswamiengar, 276).

**Jelletite** — *see* **Garnet**

**Jelutong** — *see* **Dyera**

**Jequirity** — *see* **Abrus**

**Jersey Cudweed** — *see* **Gnaphalium**

**Jerusalem Artichoke** — *see* **Helianthus**

**Jew's Mallow** — *see* **Corchorus**

**Jimson Weed** — *see* **Datura**

## JOANNESIA Vell. (*Euphorbiaceae*)

A small genus of trees native of Brazil. One species is cultivated in Indian gardens.

**J. princeps** Vell.

Bailey, 1947, II, 1720.

A handsome, medium-sized tree with a spreading crown and large tufted leaves at the ends of coarse branches. The tree is cultivated in many tropical countries for ornament and for its timber and medicinal seeds; in India, it is grown in gardens. Leaves alternate, digitately 3–7 foliolate: leaflets ovate, 3-4 in. long; flowers in paniculate cymes, inconspicuous; fruit large, 4–5 in. diam., coconut-like in form with large seeds containing agreeably flavoured kernels. The tree is hardy, bare of leaves only for a few days and is good for avenues. It is propagated from seed (Firminger, 374).

The seeds contain a fixed oil (48-56% of the wt. of kernel) which can be obtained by cold expression or extraction with ether. The oil, which is pale yellow in colour, has the following constants: sp. gr.$^{15°}_{15°}$, 0.923–0.926; $n_D^{40°}$, 1.465–1.471; acid val., 0.3-25; sap. val., 189–207; iod. val., 116–143; hydroxyl val., 6–9; R.M. val., 1.2; Polenske val., 0.3; and unsapon. matter, 0.9-1.2%. The fatty acid composition of the oil is as follows: myristic, 2.4; palmitic, 5.4; oleic, 45.8; and linoleic, 46.4%. Analysis of solvent-extracted meal gave the following values: moisture, 5.3; protein, 62.8; carbohydrate, 15.4; crude fibre, 4.8; and ash, 11.7% (Eckey, 583-85; Jamieson, 236).

The oil is used as a purgative, particularly in veterinary practice. It is four times as active as castor oil and has the advantage of possessing a somewhat agreeable odour, little or no taste and low viscosity. It is a semi-drying oil and may be used, after suitable treatment, in paints and varnishes. Treatment with lead and manganese resinates (Pb, 0.15% and Mn, 0.03%) at 185° for 5 hr. in an atmosphere of carbon dioxide, yields a product with satisfactory film-forming properties; the film dries in 24 hr. and withstands weathering just as well as linseed oil films. The oil may be used as fuel oil and also for the preparation of soap (U.S.D., 1947, 1493: Eckey, 585: *Chem. Abstr.*, 1944, **38**, 1384; 1930, **24**, 3667).

The bark yields (2.0–3.8%) an essential oil of dark yellow colour with a strong odour of garlic and an irritating and repulsive taste. It has the following constants: $d_{4}^{20°}$, 0.9225; $n_{D}^{20°}$, 1.5226; and $[\alpha]_{D}$, +3 to +4.5°. The oil contains a free acid (3.5%), eugenol (0.55%), a terpene (12.5%), sesquiterpenes (45.5%), sulphur-containing compounds, an alcohol, and a drastic vesicating resin (1.7–1.95%) (Freise, *Perfum. essent. Oil Rec.*, 1935, **36**, 219).

The seeds are purgative; they are also considered anthelmintic. The fruit and the milky latex obtained by incising the bark are used for stupefying fish. The wood is white or yellowish, coarse-textured, light and soft. It is used as rough lumber in Brazil (U.S.D., 1947, 1493: Wehmer, II, 1275: Record & Hess, 161).

**Job's Tears** — *see* **Coix**

**Johnson Grass** — *see* **Sorghum**

**Johore Drug** — *see* **Cephaelis**

## JUGLANS Linn. (*Juglandaceae*)

A genus of trees distributed in North and South America and from South Europe to East Asia. Commonly known as WALNUTS, some of the species are extensively grown for timber and fruit. One species occurs in India.

*F.R.I., Dehra Dun. Photo: A. L. Griffith*

FIG. 155. JUGLANS REGIA

FIG. 156. JUGLANS REGIA—NUTS AND KERNELS OF TWO VARIETIES

**J. regia** Linn. COMMON WALNUT, PERSIAN WALNUT, EUROPEAN WALNUT

D.E.P., IV, 549 : C.P., 700 : Fl. Br. Ind., V, 595.

TRADE—*Akhrot, akrut, akhor, krot.*

A large, deciduous, monoecious tree with tomentose shoots, found throughout the Himalayas and hills of Assam at altitudes of 3,000–11,000 ft. Bark grey, longitudinally fissured ; leaves alternate, imparipinnate, 6–15 in. long: leaflets 5–13, subsessile, elliptic to oblong-lanceolate, 3–8 in. × 1.5–4 in., usually entire ; flowers small, yellowish green: male in pendulous slender catkins, 2–5 in. long, female in 1–3 flowered, terminal catkins : fruit a green drupe with leathery exocarp, indehiscent, ellipsoid-globose, c. 2 in. across: endocarp hard, woody, wrinkled, 2-valved, enclosing 4-lobed, corrugated, oily, edible seed. A number of varieties of *J. regia*, based on geographical distribution and characters of the nut-shell (endocarp), have been recognised.

Common walnut occurs in natural forests either in pure crops or in mixture with other broad-leaved species or conifers and often attains a height of 80–100 ft. and a girth of 10–15 ft. or more. When grown as a fruit tree, it is trained to have a spreading crown and a comparatively short bole.

Under natural conditions, the fruits fall to the ground under and around the tree, the exocarp cracking and rotting off. The nuts, however, are subject to attack by birds, monkeys and rodents, and large quantities of them are destroyed. A covering of earth or debris over the nuts and a fair degree of warmth and soil moisture are necessary for germination. Natural reproduction takes place on gentle slopes with loose, but deep, fairly moist soil ; where boulders and rock fragments are plentiful, they act as a protection to nuts. Good crops of walnut are found on detrital accumulations formed by the weathering of cliffs or erosion of hillsides and on deep loose rubble on landslips in the open. Walnut is a light demander, though it stands slight shade in youth. It coppices well.

Walnut plantations for timber purposes may be raised by direct sowing or transplanting nursery seedlings. In the former case, the nuts are sown at a

depth of *c.* 2 in. For transplanting, nursery seedlings are raised in prepared beds of rich mould in warm situations. Nuts are usually sown in December-February in drills *c.* 9 in. apart, the distance between nuts being 3–4 in. The beds are watered regularly till the rainy season. Seedlings may be transplanted in the following cold season after trimming the taproot if necessary. If larger seedlings are required for transplanting, the plants are pricked out with a spacing of 1–1.5 ft. and tended till the second winter. Planting in the field should be somewhat close in order to prevent branching; on gentle slopes or level ground, a spacing of 6 ft. × 6 ft. is considered suitable; on steeper slopes, the spacing allowed is 5 ft. in contour lines 8–9 ft. apart.

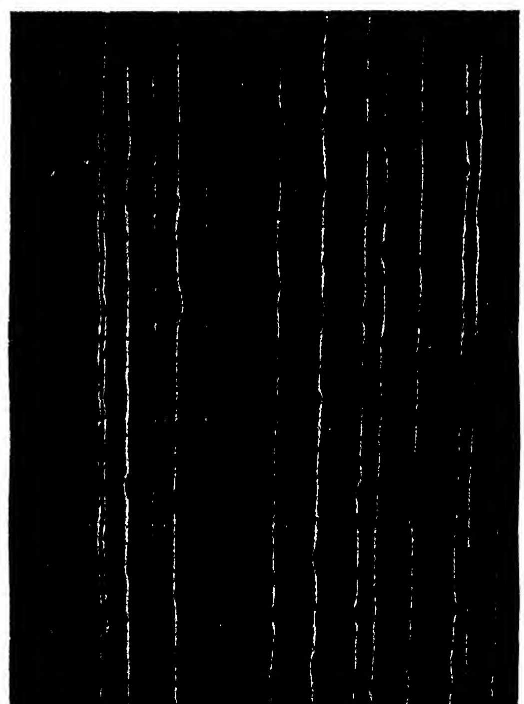
Natural reproduction in the Himalayas cannot be relied upon for systematic silvicultural treatment. The only system which appears to be applicable is that of clear felling with artificial reproduction. The western regions of the Himalayas are well adapted for growing walnut in dense, pure, even-aged crops, and natural forests answering this description are occasionally met with. The trees are tall, straight and clean-boled. The mean annual girth increments recorded in different parts of Himalayas vary from 0.42 to 1.92 in.; the growth rate increases from the western to the eastern Himalayas, depending on the total rainfall (Troup, III, 894–900; *Indian For.*, 1952, **78,** 367).

A number of fungal diseases have been reported on walnut. *Fomes fomentarius* (Linn.) Fr., *F. geotropus* Cke., *F. robustus* Karst., *Polyporus picipes* Fr., *P. squamosus* (Huds.) Fr. and *Stereum fasciatum* Schwein. cause white rot in wood. They usually affect felled timber and cut stumps; some of them, e.g. *Fomes fomentarius* and *Polyporus squamosus*, occasionally affect living trees. The organisms enter the tree through wounds caused by excessive pruning, lopping or fire. Discontinuation of such practices affords protection. Felled timber can be protected by quick extraction from forests and storage under sanitary and hygienic conditions. *Marsonia juglandis* (Lib.) Sacc., *Microstroma juglandis* (Bereng.) Sacc., *Phyllactinia corylea* (Pers.) Karst. and *Tubercularis vulgaris* Tode cause leaf spot in walnut. The disease is controlled by spraying Bordeaux mixture. Dusting with sulphur at the rate of 15 lb. per acre provides a preventive measure against powdery mildew (*Phyllactinia corylea*) [Information from F.R.I., Dehra Dun; Vasudeva, *Indian Fmg, N.S.*, 1956-57, **6** (7), 45].

Among the insect pests of walnut, two species of borers, *Aeolesthes sarta* Solsky and *Batocera horsfieldi* Hope infest living trees and spoil the timber. As control measures, badly infested and killed trees should be felled and removed, and larvae destroyed by opening ejection holes and filling up galleries with tar or viscous oil. Freshly felled trees are liable to attack by several species of coleopterous borers which are, however, of secondary importance. Walnut weevil, *Alcides porrectirostris* Mshll., which feeds on leaf buds, petioles, female floral buds and young fruits, causes great damage. Infested fruits turn black and drop to the ground, usually from April to August. Removal and destruction of fallen fruit and spraying of trees with copper sulphate-lime mixture (copper sulphate, 6 lb.; lime, 18 lb.; and water, 50 gal.), five or six times during the season, affords control [Information from F.R.I., Dehra Dun; *Hort. Abstr., India,* 1951, **1**(1), 10].

### WALNUT WOOD

Walnut wood is greyish brown in colour, often figured or mottled with darker streaks; sapwood broad, greyish white. The wood is moderately hard, strong, straight-grained, medium- and even-textured. Depending upon the variety from which it is



*F.R.I., Dehra Dun. Photo: K. A. Chowdhury*

FIG. 157. JUGLANS REGIA—TRANSVERSE SECTION OF WOOD (×10)

derived the wood varies in colour, markings, weight (28–46 lb./cu. ft.) and other mechanical properties.

The wood seasons slowly and requires considerable attention. Warping and surface cracking are negligible, but the wood shrinks while drying and, unless care is taken, it is liable to develop fine deep splits. Green conversion, followed by stacking under cover with good air circulation, has been recommended. End-painting of planks helps to reduce end-splits. Kiln-seasoning gives good results: planks of 1 in. thickness take 13–16 days to season: in addition to the initial steaming, two intermediate and one final steaming at 55° for 2–4 hr. are recommended (Pearson & Brown, II, 951–55; Trotter, 1944, 123–24; Rehman, *Indian For.*, 1953, **79,** 369).

The comparative suitability of different varieties of walnut wood as timber, expressed as percentages of the same properties of teak, are as follows: wt., 80–90; strength as a beam, 70–80; stiffness as a beam, 70–90; suitability as a post, 65–80; shock-resisting ability, 90–115; retention of shape, 50–75; shear, 90–120; and hardness, 65–75. Walnut timber is durable under cover, but not so in exposed situations. It is not particularly resistant to white ant and fungus attack. Graveyard tests at Dehra Dun indicated a durability of about two years. It does not require any antiseptic treatment: a colourless preservative may be applied by brushing [Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 18; Pearson & Brown, II, 954; Trotter, 1944, 123].

The wood is easy to saw and work. It is suitable for high speed machining and turning, and lends itself in a marked degree to carving. It finishes to a smooth shiny surface, takes a fine polish and needs very little filling.

Walnut is one of the best woods for furniture and carving, and beautiful walnut furniture made in Kashmir may be seen in many parts of the world. The importance of the wood, however, lies in its suitability for rifle parts and gunstocks, and the Indian Ordnance Department consumes the major portion of the output. Walnut wood gives extremely beautiful veneers and plywood, and is much esteemed for cabinet making, musical instruments, inlay and other ornamental work; wood with warts or burrs is especially valued, but the supply is limited. Walnut wood is also used for ploughs, handlooms, shafts, lacquer work, frames, drawing instruments, fancy articles, bobbins, etc. It is employed for propeller blades of aeroplanes (Pearson & Brown, II, 955; Trotter, 1944, 124; Howard, 627; Dastur, Useful Plants, 132; *Indian For.*, 1952, **78,** 367; Rehman, *Indian For.*, 1953, **79,** 369).

Analysis of wood (dried at 110°) gave the following values: rosin and fat, 6.0; water-solubles, 6.5; methoxyl, 6.4; acetyl, 3.2; lignin, 22.2 (methoxyl in lignin, 19.6); pentosans, 19.5; slightly soluble xylan, 8.3; easily soluble xylan, 6.2; and cellulose, 48.4%; calcium oxalate is present (*Chem. Abstr.*, 1938, **32,** 8772; Wise & Jahn, I, 650).

### Walnut Fruit

Kashmir is the principal walnut growing State in India; the acreage under walnut in the State (*c.* 8,000 acres) exceeds that under any other fruit crop except apple. It is estimated that some 1,14,000 trees are found growing, scattered and in groves, in the State. Other walnut growing regions are the hilly areas of Punjab, Himachal Pradesh and Uttar Pradesh, but the quality of produce from these regions is not usually as good as that from Kashmir. Since the trees are large and spreading, requiring wide spacing (40–50 ft.), farmers are not enthusiastic about growing walnut in cultivable areas. It is mostly grown in unreclaimed and poor soil, on terraces or near dwellings. Even in these situations they grow fairly well and yield variable quantities of nuts over long periods. Walnut does not do well on the hills of South India (Information from the Indian Coun. agric. Res., New Delhi; Hayes, 395).

*Climate and soil*—Walnut requires a climate free from frost in spring and extreme heat in summer. A temperature of even 2–3°F. below freezing point kills young flowers; if the summers are hot (100° F. and above in shade and low humidity), the nuts get sun-burnt and become 'blanks'. Walnut thrives well in areas with an annual rainfall of 30 in. or more. Other conditions being favourable, deficiency in rainfall can be made up by artificial irrigation.

The soil should be deep and well-drained; silt loam, 8–10 ft. deep, containing abundant organic matter gives the best results. The soil should not have a fluctuating water level, hard pan, sandy subsoil or alkali. Trees growing on shallow soil with low moisture are more liable to sun-burn than those growing on deep silt soil.

***Propagation***—The trees are usually raised from seedlings. In certain parts of Himachal Pradesh and Kulu valley, planting of walnut is considered inauspicious; even seedlings of selected trees are not planted. Only seedlings that come up in nature are allowed to grow and this has resulted in a

preponderance of inferior or mediocre type of trees. In Kashmir, planting of seedling walnuts is popular; about 10,000 trees are reported to be planted every year, out of which some 6,000 survive.

Nuts for raising seedling plants should be collected from vigorous and high-yielding trees. Desirable characters to look for in the selection of nuts are the following: big size: bright brown shell of good cracking quality: and bright yellow kernel with good taste and flavour. Nuts should be stored in a cool dry place or stratified after harvest till the following December. If the soil is ready for sowing, beds may be prepared and nuts sown c. 2 in. deep immediately after harvest in rows 1 ft. apart, the distance between sowings in the row being 1 ft. Germination starts in the beginning of March and seedlings are ready for transplanting in the second year.

Walnut is propagated in other countries by vegetative methods; the methods in use are: whip grafting, cleft grafting, inlay bark grafting and patch budding in early spring. In Kashmir, patch budding and crown grafting have been tried and found successful, but these methods have not been adopted on any appreciable scale. The improvement of walnut cultivation in India is dependent on the introduction of budded and grafted trees of good varieties. No systematic attempt appears to have been made so far to introduce these methods.

*Cultural practices*—Walnut is usually grown under rain-fed conditions; only during the first dry season after planting is water supplied to plants by growers. It has been found advantageous to irrigate the trees during dry weather. Irrigation helps growth and trees come into bearing early. Irrigation should be continued till the maturity of fruits as it reduces nut fall and favours filling of nuts. If the trees are irrigated one or two weeks before harvest, the husks are seen to open and remain on the trees, while clean nuts drop to the ground; harvesting is thereby facilitated.

Walnut trees are seldom manured in India. On account of its deep root system, the trees forage over an extensive area and bear fairly good crops. The yields, however, are less in comparison with those of manured trees; also, unmanured trees tend to become alternate-bearing. It is a good practice to manure the trees every year and also apply nitrogenous and phosphatic fertilisers, the doses depending upon the age, size and bearing quality of trees, and on the fertility of soil.

Practically no pruning is given to walnut trees. The trees should be trained on a single stem up to a height of 3–4 ft. and scaffold branches should be retained at proper places. Any crossing or surplus branches and diseased and dry twigs should be removed every year.

Walnut is self-fertile, but pollination is not satisfactory in some varieties in certain years, because of the failure of pollen to mature at the time female flowers are receptive. The pollen is distributed by wind and may be carried up to a mile; the effective range is 200–300 ft. New plantations of walnuts, if located near existing bearing trees, will, therefore, start fruiting at an earlier age and yield greater quantities of nuts than those located far away from bearing trees. The pollen of any one variety is capable of fertilising its own pistils or the pistils of any other variety. Good and poor crops in Kashmir are generally associated with prevailing weather conditions, especially at the time of flowering.

*Harvesting and marketing*—Walnut fruits ripen in September–October. The husks split at the time of maturity and the nuts which fall to the ground are collected. Nut-fall is hastened by shaking the branches with hand or with bamboo poles to the ends of which hooks are attached; shaking is repeated 2–3 times at intervals. After collection, nuts are cleaned, washed and dried by spreading on floor or canvas sheets. Nuts which fall to the ground with husks are generally of inferior grade; after removing the husks, cleaning and drying, they are marketed separately. Before marketing, the nuts are graded according to size and colour. In some areas, nuts are bleached by dipping in a mixture of aqueous solution of chloride of lime and sodium carbonate; the mixture is allowed to settle and the clear solution used for dipping. Dilute chlorine solution may also be used for bleaching (Jacobs, II, 1578; von Loesecke, 344).

The tree starts to bear crop at the age of 8–10 years. The yield of nuts varies according to the age, size and variety of tree. Outer branches produce the best fruit. A grown up tree of big size may yield 4–5 md. of nuts. However, considering the on and off years and varying ages of trees, the average yield per tree may be taken as one maund. The average annual income per tree in Kashmir is estimated at Rs. 20; it is less in other States. The bearing life of the tree is about 100 years.

Walnuts are stored in gunny bags in ventilated rooms free from excessive humidity. For export, they

are packed in cases lined with paper. Walnut kernels are also despatched to far off places in boxes (Information from the Indian Coun. agric. Res., New Delhi).

Deterioration of walnuts during harvesting, transit and storage is brought about by insects, fungi and moisture. Insect infestation occurs usually during the interval between harvesting and packing, and can be controlled by fumigation with methyl bromide. The darkening of kernels is due to mould growth, the infection occurring during the loosening of hulls from shells, which usually takes 10–28 days. Ethylene treatment at 21–32°, whereby the hulls are loosened in about 60 hr., has been tried in California: the treatment does not affect the flavour or the keeping quality of nuts (*Bull. cent. Fd technol. Res. Inst., Mysore*, 1956, **5**, 146; *Food Sci. Abstr.*, 1952, **24**, 277).

*Trade*—Walnuts are collected from trees raised from seedlings and no named varieties exist. The most esteemed among cultivated varieties is *Kaghzi akhrot*, a large nut with easily breakable thin shell and whitish kernel of excellent taste and flavour.

The annual production of walnuts in Kashmir is estimated at 57,000 maunds. The major part of the production is sent to other parts of India or exported to outside countries, local consumption being mostly confined to undersized or otherwise rejected nuts. Considerable quantities of walnut are imported from West Pakistan, Afghanistan and Persia.

Table 1 gives the quantity and value of exports of walnut during 1953–54 to 1956–57. The demand from overseas markets, especially from U.S.A., for walnut kernels, is reported to be on the increase. There is considerable scope for increasing the export trade, provided proved varieties are cultivated and the produce from existing trees is properly graded (Information from the Indian Coun. agric. Res., New Delhi).

TABLE 1—EXPORT OF WALNUTS FROM INDIA

| | Quantity cwt. | Value Rs. |
|---|---|---|
| 1953–54 | 90,218 | 1,22,71,193 |
| 1954–55 | 104,794 | 1,16,73,606 |
| 1955–56 | 64,451 | 95,92,723 |
| 1956–57 | 73,334 | 96,97,501 |

*Composition and uses*—Walnut is esteemed as dessert and dry fruit during winter, particularly in North India. It is also much prized in confectionery and ice creams.

The edible kernel constitutes about half the weight of the whole nut. Californian kernels contain: moisture, 2.5; protein, 14.3–20.4; fat, 60–67; N-free extr., 14.5–19.1; fibre, 1.4–3.2; and ash, 1.2–1.6%. Analysis of Indian kernels gave the following values: moisture, 4.5; protein, 15.6; ether extr., 64.5; carbohydrates, 11.0; fibre, 2.6; and mineral matter, 1.8%. The following mineral elements are reported to be present: sodium, 2.7; potassium, 687; calcium, 61; magnesium, 131; iron, 2.35; copper, 0.31; phosphorus, 510; sulphur, 104; and chlorine, 23 mg./100 g.; iodine (2.8 μg./100 g.), arsenic, zinc, cobalt and manganese. About 42% of the total phosphorus is in the form of phytic acid; lecithin is also present (Thorpe, XI, 883; *Hlth Bull.*, No. 23, 1951, 42; McCance & Widdowson, 83, 148; Winton & Winton, I, 396; Iodine Content of Foods, 103; Young, *Sci. Progr.*, 1956, **44**, 21).

A globulin, juglansin, has been isolated from the edible kernel. The nitrogen distribution of the globulin (total N, 18.84%) is as follows: basic (diamino) N, 5.41; non-basic (monoamino) N, 11.51; humin N, 0.15; and amide N, 1.78. The globulin contains cystine (2.18%) and tryptophane (2.84%) (Winton & Winton, I, 395).

Vitamins of the B group reported to be present in the kernel are: thiamine, 0.33–0.40; riboflavin, 0.10–0.16; nicotinic acid, 0.58–0.81; pantothenic acid, 0.49–0.98; folic acid, 0.13–0.23; and vitamin $B_6$, 0.87–1.05 mg./100 g.; biotin, 2 μg./100 g. The kernel contains also vitamin A (30 i.u./100 g.) and ascorbic acid (3 mg./100 g.). Only small percentages of thiamine, riboflavin and nicotinic acid are lost as a result of storing the kernels (Jentsch & Morgan, *Food Res.*, 1949, **14**, 40; 1953, **47**, 5575; *Food Sci. Abstr.*, 1954, **26**, 457; 1950, **22**, 210; Watt & Merrill, *Agric. Handb. U.S. Dep. Agric.*, No. 8, 1951, 50).

The immature fruit is one of the richest sources of ascorbic acid. The maximum concentration of ascorbic acid (2–2.5% on fresh wt., 16–20% on dry wt.) is reached just before the shell hardens. The distribution of ascorbic acid in fresh immature fruits from Kashmir is as follows: whole fruit, 1470; skin, 1090; and pulp, 2330 mg./100 g. Pickles, marmalades, chutneys, press juice, and syrups rich in ascorbic acid can be prepared from immature fruits. The concentration of the acid, however, falls rapidly

during storage unless pre-treated with sulphur dioxide. Press juice and dehydrated products prepared from the immature fruit are bitter (Klose *et al., Industr. Engng Chem.*, 1950, **42,** 387; Pyke *et al., Nature, Lond.*, 1942, **150,** 267; Ranganathan, *Indian J. med. Res.*, 1942, **30,** 513; *Chem. Abstr.*, 1939, **33,** 1405; 1946, **40,** 410).

Green hulls separated from mature walnuts contain 0.4–0.8% of ascorbic acid (2.5–5.0% on dry wt.). A process has been developed for the recovery (up to 25–50%) of the ascorbic acid present; it involves the following steps: extraction of material with water containing sulphur dioxide, purification of extract with anion-exchange resins, and crystallization. The ascorbic acid present in hulls is rapidly destroyed at room temperature, more than 60% being lost within 8 hr. The hulls may be preserved in an aqueous solution of sulphur dioxide (1.5%) without loss of the vitamin for 5 months at room temperature; in the frozen state (0°F.), the acid is stable for 1 year or more (Klose *et al.*, loc. cit.).

Unripe fruit and other parts of the plant contain a substance which reduces indophenol dye, but does not possess antiscorbutic activity; this substance has been identified as $\alpha$-hydrojuglone glucoside ($C_{16}H_{18}O_8$) which on hydrolysis yields glucose and $\alpha$-hydrojuglone (1, 4, 5-trihydroxynaphthalene); the latter on oxidation yields juglone ($C_{10}H_6O_3$, 5-hydroxy 1,4-naphthoquinone; m.p., 153-54°). The glucoside forms up to 15% of the total indophenol dye reducing material in immature walnuts or mature hulls; its concentration is particularly high in very young fruits and in resting buds and catkins. Another reducing substance, probably a flavanone, has been reported to be present in the leaves (Melville *et al., Nature, Lond.*, 1943, **152,** 447; Daglish & Wokes, ibid., 1948, **162,** 179; Klose *et al., Plant Physiol.*, 1948, **23,** 133; Wokes & Melville, *Biochem. J.*, 1949, **45,** 343; Daglish, ibid., 1950, **47,** 452, 458, 462).

*Walnut oil*—The kernels yield 60–70% of a drying oil, known in the trade as Walnut Oil. The oil is pale greenish yellow or almost colourless with a pleasant odour and a nutty flavour. It has the following range of constants: sp. gr.$^{25°}_{25°}$, 0.921–0.924; $n_D^{40°}$, 1.469–1.471; iod. val., 138–152; sap. val., 190–197; solidification pt., −12 to −20°; titre, 14-16°. The fatty acids present are: palmitic, 3–7; stearic, 0.5–3; oleic, 9–30; linoleic, 57–76; and linolenic, 2–16% (Jamieson, 332; Williams, K. A., 277-78; Eckey, 379).

Walnut oil is used for edible purposes; small quantities are used for artists' oil colours, printing inks, varnishes and for making soap. The oil dries rather slowly; heat treatment improves the drying properties. The varnish prepared from the oil is pale, non-yellowing and less liable to crack than linseed oil varnish. The supply of oil is limited owing to the demand for kernels. In U.S.A., walnut oil is expressed from waste meats from shelling plants and occasionally from surplus nuts. The oil is sometimes adulterated with poppyseed and linseed oils (Hill, 196; Eckey, 379; Jordan *et al.*, 73; Allen, II, 216, 218).

The oilcake is rich in proteins and is used as cattle feed. Its composition and nutritive value are as follows: dry matter, 86.6; protein, 35.0; fatty oil, 12.2; carbohydrates, 27.6; fibre, 6.7; and ash, 5.1%; *digestible nutrients*—crude protein, 31.5; fatty oil, 11.6; carbohydrates, 23.5; and fibre, 1.7%; nutritive ratio, 1.7; and starch equivalent, 78.5 (Williams, K.A., 278; Woodman, *Bull. Minist. Agric., Lond.*, No. 124, 1945, 14).

*Walnut shells*—Analysis of walnut shells gave the following values: dry matter, 92.3; protein, 1.7; fatty oil, 0.7; carbohydrates, 31.9; fibre, 56.6; and ash, 1.4% (Woodman, *Bull. Minist. Agric., Lond.*, No. 124, 1945, 21).

Walnut shell flour is used as a filler in moulded plastics; it can be used up to 40% as an extender in resin adhesives. Shell flour contains cellulose, lignin (28%), furfural (5%), pentosans (9%), methylhydroxylamine (6%), sugar, and starch (2.5%). Shells may be used as an antiskid agent for car and tractor tyres, as blasting grit for loosening coatings and deposits on metals, and in the preparation of activated carbon (Brady, 767; *Chem. Abstr.*, 1953, **47,** 3030, 2676; 1954, **48,** 6101; *Sci. News Lett., Wash.*, 1953, **64,** 55).

*Leaves*—Fresh leaves, like unripe fruit, are rich in ascorbic acid (800–1,300 mg./100 g. green wt.). Leaves may be preserved by exposing them to sulphur dioxide gas and then rapidly drying at 100–110°; treated leaves may be pressed or extracted with water to obtain concentrates of ascorbic acid (recovery, 80–93%). The leaves are also rich in carotene (30 mg./100 g. green wt.). Concentrates of carotene may be prepared from fumigated leaves (*Chem. Abstr.*, 1946, **40,** 3231).

On steam-distillation, the leaves yield an olive brown volatile oil, with an odour reminiscent of tea

and amber. Oils distilled from fresh leaves, from Germany (yield, 0.012–0.029%), had the following ranges of constants: $d^{30°}$, 0.9037–0.9137; $[\alpha]_D$, nil; acid val., 9.3–16.8; ester val., 18.4–27.0; soluble in alcohol (90%) with separation of a paraffin (m.p., 61–62°); the paraffin separates out also on cooling the oil. The constants of the oil examined in France (yield, 0.0087%) were as follows: $d^{30°}$, 0.9185; $[\alpha]_D$, −17.0°; $n^{25°}$, 1.4922; and ester val. after acetylation, 98.5 (Finnemore, 205; Gildemeister & Hoffmann, II, 317).

Aqueous extracts of fresh leaves, free of juglone, possess strong bactericidal action against *Bacillus anthracis* and *Corynebacterium diphtheriae;* it is weakly active against *Vibrio comma, Bacillus subtilis, Pneumococci, Streptococci, Micrococcus pyogens* var. *aureus, Proteus, Escherichia coli, Salmonella typhosa, S. typhimurium* and *S. dysenteriae*. The extracts are not toxic to mice (*Chem. Abstr.*, 1955, **49,** 14095).

Twigs and leaves of walnut are lopped for fodder. The leaves contain (moisture-free basis): N, 3.22; and ash, 11.57% (George & Kohli, *Indian For.*, 1957, **83,** 287).

Green walnut hulls, shells, bark and leaves are used for dyeing and tanning. They contain tannin (hulls, 12.23; bark, 7.51; mature leaf blades, 9–11%) and juglone. The bark is sold in bazaars under the name *Dundasa* and is used for cleaning teeth or for chewing to redden the lips. Green walnut shells have been used as hair dye in the form of an oily extract or alcoholic extract mordanted with alum. Juglone imparts a brownish yellow colour on mordanted wool and a rose tint on mordanted cotton. The colours are inferior to synthetic dyes in fastness, particularly against light (*Chem. Abstr.*, 1941, **35,** 4209; 1944, **38,** 3844; 1954, **48,** 11000; Puran Singh, *Indian For.*, 1918, **44,** 339; Howes, 1953, 280; Poucher, III, 82; Mayer & Cook, 105).

Walnut leaves are astringent, tonic and anthelmintic. The leaves and bark are alterative and detergent; they are used in herpes, eczema, scrofula and syphilis; the fruit is reported to be used as alterative in rheumatism. The vinegar of pickled young fruit is used as gargle for sore throat. Green hull and unripe shell are anti-syphilitic and vermifugal. The expressed oil of the fruit is considered useful against tapeworm and as a laxative injection. In Malaya, kernels are recommended in colic and dysentery. The rind of the unripe fruit is used as fish poison (Kirt. & Basu, III, 2348; U.S.D., 1955, 1728; Chopra *et al.*, *J. Bombay nat. Hist. Soc.*, 1940–41, **42,** 854).

**Jujube** — *see* **Zizyphus**

**JUNCELLUS** Griseb. (*Cyperaceae*)

Fl. Br. Ind., VI, 594; Kirt. & Basu, Pl. 1009A.

A small genus of perennial, tufted herbs found in the warm and temperate regions of the world. Six species are recorded in India.

*J. inundatus* C.B. Clarke = *Cyperus serotinus* Rottb. var. *inundatus* (Roxb.) Kukenthal (HINDI & BENG. — *Pati*) is a stout rhizomatous herb, 1–3 ft. high, with stem triquetrous at the top and long leaves, found in swampy situations in Bihar, West Bengal and Sundarbans. The tubers are considered tonic and stimulant (Kirt. & Basu, IV, 2636).

**JUNCUS** Linn. (*Juncaceae*)

A large genus of perennial, rarely annual, herbs constituting the Rushes, distributed in arctic, temperate and, occasionally, tropical regions. About 30 species are recorded in India.

**J. effusus** Linn. syn. *J. communis* E. Mey. SOFT, COMMON OR MATTING RUSH

D.E.P., IV, 552; C.P., 776; Fl. Br. Ind., VI, 392.

A densely tufted, cylindrical and soft perennial herb, 1–3 ft. high, found in Sikkim Himalayas (6,000–10,000 ft.) and Khasi (5,000–5,500 ft.) and Aka hills, in wet and marshy situations. Leaves short, sheathing the base of stem; inflorescence variable, effuse, lax or pendulous; flowers in clusters, greenish or brownish; capsules obovoid; seeds minute.

The rush is used for making mats, baskets and chair bottoms. It is used for tying parcels in China. A fine straw is prepared from it in Philippines. The pith of the stem is used as wick for lamps and candles (Burkill, II, 1271–72; Brown, 1941, I, 365).

The leaves contain (dry basis): protein, 8.6; amide, 1.6; N-free extr., 54.3; fat, 2.4; fibre, 31.0; and ash, 3.6%. The leaves also contain glucose (but no sucrose), traces of bases and organic acids, pentosans, some methyl pentosans, and small quantities of fat with fatty acids. The leaves contain 64% cellulose; a fibre which can be spun into thread is obtained from alkali digested (2% caustic soda) pulp of the grass (Wehmer, I, 140; *Chem. Abstr.*, 1941, **35,** 6809).

A decoction of the pith is considered antilithic, pectoral and discutient. In China, the pith is used as diuretic and depurative, and is employed for keeping fistulous sores open. The root is diuretic especially in

strangury. The plant is reported to be poisonous to cattle (Burkill, II, 1272 ; Roi, 72 ; Steinmetz, II, 256 ; Watt & Breyer-Brandwijk, 10).

**J. inflexus** Linn. syn. *J. glaucus* Ehrh. ex Sibth. HARD RUSH

D.E.P., IV, 552 ; C.P., 776 ; Fl. Br. Ind., VI, 393 ; Fyson, II, Pl. 557.

A tufted, dark green perennial herb with cylindrical stem, 1–2½ ft. high, found usually in damp situations and distributed from Kashmir to Nepal, Aka hills, Nilgiri and Pulney hills, and the southern end of western ghats, ascending from 6,000 to 9,000 ft. Leaves none or cylindrical like the stem ; flowers minute, brown, sessile, solitary ; capsules ovoid, pointed.

The rush may be used for making mats and baskets in the same way as *J. effusus*. It is used as fodder in times of scarcity ; cattle do not relish it at the beginning, but once the taste is acquired, they take to it greedily. It is reported to be poisonous to animals causing irritation of stomach and diarrhoea followed by rapid loss of condition, nervousness and progressive blindness ; the animals may die of cerebral haemorrhage preceded by convulsions. Inhalation of chloroform together with subcutaneous injection of brandy and camphor in ether provides relief ; animals gradually recover and they should be kept indoors for a long time (Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 87).

*J. prismatocarpus* R. Br. is a tufted, perennial herb, 1½–2 ft. high, found in the Himalayas, from Punjab to Assam, up to 10,000 ft. ; it is also found in Madras, western ghats and Kerala in marshy places, pools and river banks. It is reported to be cyanogenetic (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 66).

**Jungle Fowl** — *see* **Birds**

## JUNIPERUS Linn. (*Pinaceae*)

A genus of evergreen aromatic shrubs or trees, distributed chiefly in the northern hemisphere, from the arctic zone to the mountains of the tropics. Some of the species furnish commercial woods suitable for pencil making ; some are of medicinal importance. Five species occur in India and a few exotics have been introduced.

Junipers are ornamental plants with branchlets spreading in all directions. They vary greatly in habit ; the erect columnar or pyramidal forms are decorative and are excellent for narrow avenues ; those of bushy habit may be grown in hedges ; the spreading kinds provide a good covering for ground in semi-wild places ; some species are useful for re-afforestation purposes.

Junipers are well adapted for medium and high elevations in India. They thrive best in sandy and loamy, moderately moist soil, but grow well even in rather dry, rocky and gravelly ground. They prefer sunny open situations and can be propagated by seeds, cuttings, layers or by grafting. Seeds retain their viability, when stored in a cool dry place, for several years. When sown they often take a year to germinate, though sometimes they may vegetate in a few weeks. Germination may be hastened by soaking the seeds in hot water for a few minutes before sowing (Dallimore & Jackson, 291 ; Chittenden, III, 1092 ; Firminger, 283).

**J. communis** Linn. COMMON JUNIPER

D.E.P., IV, 552 ; Fl. Br. Ind., V, 646 ; Kirt. & Basu, Pl. 922B.

HINDI—*Aaraar, hauhera, abhal* ; BENG.—*Havusha* ; MAR.—*Hosha*.

PUNJAB & KASHMIR—*Betar, petthri, pama, chui, haulber* ; KUMAON—*Chichia, jhora* ; DECCAN—*Abhal*.

A dense, more or less procumbent shrub, rarely a small tree, found in the Himalayas from Kumaon westwards at altitudes of 5,000–14,000 ft. Bark reddish brown, peeling off in papery shreds ; leaves in whorls of 3, linear-subulate, 0.2–0.6 in. long, sharply pointed, upper surface concave, glaucous, bluish white, lower surface bluntly keeled ; flowers usually dioecious, axillary ; fruit sub-globose, bluish black when ripe, 0.4–0.5 inch in diam., covered with a waxy bloom ; the three scales comprising the fruit occasionally gaping and exposing seeds ; seeds usually 3, elongated, ovoid. The plant is very variable with a number of geographical varieties and garden forms ; it becomes prostrate, not more than 2–3 ft. in height at higher altitudes in the Himalayas. The plant flowers in March–April and fruits ripen in August–September of the second year. Under natural conditions, the seeds are freely spread by birds, which devour the fruits (Troup, III, 1166).

Juniper fruits have a gin-like aroma and a sweet terebinthinate taste with a somewhat bitter after-taste. They are employed for flavouring gin and food products ; they are sometimes used as an article of food. Large quantities of the fruit are used in Europe for the preparation of alcoholic beverages of the gin type. For this purpose, the fruits are crushed, immersed in warm water and fermented ; the

fermented mass is then distilled and rectified; 1,000 kg. of fruits yield 16–18 litres of beverage (containing 40–50% alcohol) and 5–6 kg. of volatile oil (Thorpe, VII, 86; Hill, 450; Guenther, VI, 371–75).

Dry fruits (JUNIPERUS, JUNIPER, JUNIPERI FRUCTUS) and the volatile oil obtained from them (OIL OF JUNIPER, OLEUM JUNIPERI) are included in I.P.C.; B.P.C. includes only the oil. According to I.P.C., juniperus should contain ⋫10% immature or discoloured fruits, ⋫3% foreign organic matter, and ⋫2% acid-insoluble ash (I.P.C., 127–28).

The fruits contain, besides the volatile oil, fermentable sugars (33%), resin (8%), juniperin (probably a mixture of tannin and sugars, 0.36%), fixed oil, proteids, wax, gum, pectins, organic acids (formic, acetic, malic, oxalic and glycolic) and potassium salts. They are a good source of ascorbic acid (*c.* 35 mg./100 g.). The fruits and the volatile oil possess carminative, stimulant and diuretic properties and are useful in different forms of dropsies, especially in conjunction with other drugs. They have been used in disorders of the urino-genital tract, such as gonorrhoea, gleet and leucorrhoea, and in certain cutaneous diseases. Dried fruits are sold in the bazaars of North India and are reported to be imported from Nepal via Patna (Thorpe, VII, 86; Wehmer, I, 45; Nadkarni, I, 710; *Chem. Abstr.*, 1940, **34,** 849; 1952, **46,** 1716; 1948, **42,** 3096; Kirt. & Basu, III, 2380–81; U.S.D., 1955, 733–34).

Juniper oil is obtained by steam-distillation of ripe fruits, the yield varying from 0.8 to 1.6% according to the quality of fruits distilled. The oil from green unripe fruits is inferior; in overripe fruits, the oil changes into a resin. The bulk of the commercial oil is obtained as a by-product during the distillation of alcoholic beverages. The oil, however, is inferior to that obtained by the direct distillation of fruits as it is partly deprived of the natural oxygenated odoriferous compounds (Guenther, VI, 375; *Chem. Abstr.*, 1943, **37,** 6405).

Juniper oil is a colourless or pale greenish yellow limpid liquid with a characteristic odour of the fruit and a somewhat burning bitter flavour. On storing, the oil turns viscous and acquires a turpentinic odour. The characteristics of fresh oil obtained by the steam-distillation of the ripe fruits, usually vary within the following limits: sp. gr.$^{15°}$, 0.867–0.882; $n_D^{20°}$, 1.472–1.484; $[\alpha]_D$, up to $-13°$ (occasionally dextro-rotatory); acid val., up to 3; ester val., 1–12; and ester val. after acetylation, 19–31; solubility in 90% alcohol, 1 in 5–10 vol., becoming less soluble with age. The fruits obtained from Hoshiarpur (Punjab) market gave an oil (yield, 0.83%) with the following constants: sp. gr.$^{27°}_{4°}$, 0.918; $n_D^{26.5°}$, 1.482; $[\alpha]_D$, $+20.8°$; acid val., 4.7; and ester val., 20.5. The I.P.C. requirements for the oil are as follows: sp. gr.$^{20°}$, 0.862–0.892; $n_D^{20°}$, 1.476–1.484; and $[\alpha]_D$, +1 to $-15°$ (Guenther, VI, 376–77; Bhati, *J. Indian Inst. Sci.*, 1953, **35A,** 43; I.P.C., 183–84).

The oil contains *d*-*α*-pinene as the major constituent together with smaller amounts of camphene, cadinene, juniper camphor (possibly a sesquiterpene alcohol), a hydrocarbon (junene, $C_{10}H_{16}$; b.p., 164–66°) with strong diuretic properties, terpinenol, certain unidentified oxygenated compounds possessing the characteristic juniper odour, and traces of esters. (Guenther, VI, 380; Parry, I, 34).

Juniper oil is largely used in compounded gin flavours, liqueurs and cordials. A twice rectified oil has high flavour value. Imitation juniper oils have been produced (Guenther, VI, 381; Jacobs, II, 1747).

The exhausted fruits (left after the distillation of oil) on repeated extraction with warm water and concentration, yield (30–38%) a product known as SUCCUS JUNIPERI. The preparation, consisting chiefly of invert sugar, was formerly used in Europe as a diuretic and sudorific. Exhausted fruits are used as feed for stock. They contain: moisture, 23.72; crude protein, 6.23; ether extr., 10.75; crude fibre, 27.16; N-free extr., 38.0; and ash, 4.14%. The ash is rich in calcium and potassium. Feeding trials on sheep gave the following digestibility co-efficients: N-free extr., 66; protein, 39; ether extr., 37; and crude fibre, 20% (Guenther VI, 376; *Chem. Abstr.*, 1937, **31,** 8055).

All parts of the tree contain volatile oil. A terebinthinate juice exudes from the tree and hardens on the bark; it has been erroneously considered to be identical with gum Sandarac [from *Tetraclinis articulata* (Vahl) Mast.]. Terminal twigs and needles yield (0.15–0.18%) a bright yellow oil (sp. gr.$^{20°}$, 0.8531) with the characteristic odour of juniper oil; it contains *d*-*α*-pinene, camphene and cadinene. Juniper Wood Oil is obtained by the steam-distillation of wood: it has the following constants: $d^{15°}$, 0.8692; $[\alpha]_D$, $-21.03°$; $n_D^{20°}$, 1.4711; acid val., 0.9; ester val., 6.7; solubility in 90% alcohol, 1 in 7 vol. or more, with slight turbidity. It contains cadinene and a sesquiterpene. Commercial juniper wood oil is usually obtained by distilling turpentine with juniper wood and twigs; more often, it is a mixture of turpentine and juniper oil. The bark oil obtained by the steam-distillation of bark (yield, 0.25–0.50%)

contains juniperene, juniperol ($C_{15}H_{26}O$ : m.p., 110°), α-pinene and silvestrene (U.S.D., 1955, 733 : Finnemore, 13 : Wehmer, I, 45 : *Chem. Abstr.*, 1935, **29,** 8234 ; Gildemeister & Hoffmann, II, 163–64 ; *Chem. Abstr.*, 1955, **49,** 12784).

Juniper needles are rich in ascorbic acid (88 mg./100 g.) : they also contain resin, wax and esters. The fruits and roots yield brown and purple dyes respectively. The bark is said to be used in Russia for tanning (*Chem. Abstr.*, 1944, **38,** 2400 ; Nadkarni, I, 710 : Wehmer, I, 45 : *Chem. Abstr.*, 1935, **29,** 5275 ; Howes, 1953, 280).

The wood of juniper (wt., 33 lb./cu. ft.) is brownish, moderately hard, durable, fragrant, highly resinous and easy to season. It is usually available in small sizes and used for fencing, veneering, turnery and as fuel. The wood and young twigs are burnt as incense (Dallimore & Jackson, 304 : Gamble, 698).

The polysaccharides present in the wood are as follows : galactan, 13.5 ; glucosan, 61.0 ; mannan, 14.0 : araban, 0.5 ; and xylan, 11.0%. *p*-Hydroxybenzaldehyde (2.5%) has been identified among the nitro-benzene oxidation products of the wood. Sugiol (9-ketoferruginol) is reported to be present (Wise & Jahn, II, 853 ; Leopald & Malmstrom, *Acta chem. scand.*, 1952, **6,** 49 ; Bredenberg & Gripenberg, ibid., 1954, **8,** 1728).

The wood is diuretic, sudorific and blood purifier ; it is employed in gout, rheumatism and cutaneous diseases (Steinmetz, II, 256).

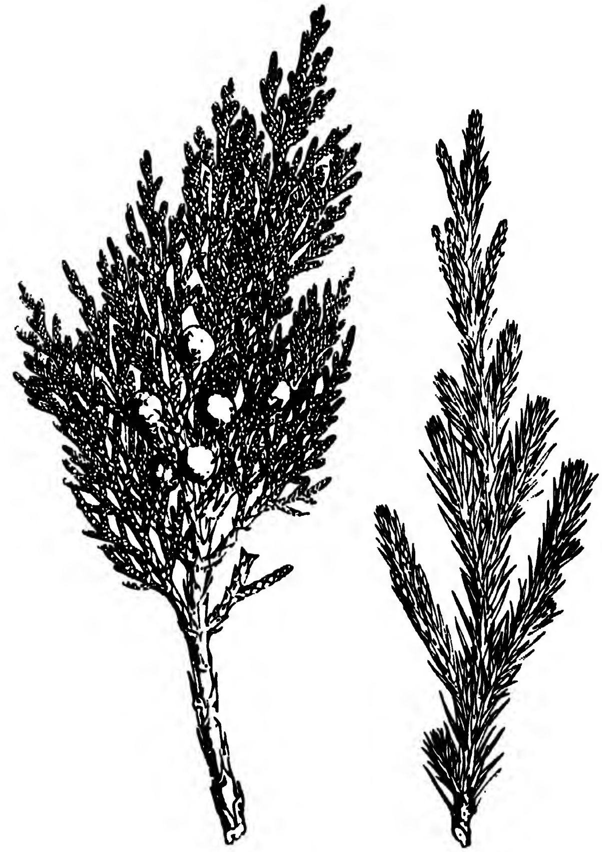


FIG. 158. JUNIPERUS MACROPODA—BRANCHES WITH SCALE-LIKE AND ACICULAR LEAVES

**J. macropoda** Boiss. INDIAN JUNIPER, HIMALAYAN PENCIL CEDAR

D.E.P., IV, 554 ; Fl. Br. Ind., V, 647.

PUNJAB—*Chalai, lewar, shukpa, shur ;* U.P. - *Dhup, padam ;* NEPAL—*Chandan, dhupi.*

A shrub or tree, 40–50 ft. in height and 6–7 ft. in girth, often with a crooked and gnarled trunk, found in the inner arid ranges of the Himalayas, from Nepal westwards, at altitudes of 5,000-14,000 ft. ; it is sometimes cultivated in the plains. Bark reddish brown, exfoliating in long fibrous strips ; leaves dimorphic : acicular on some lower branches, scale-like and closely appressed on most others : flowers monoecious : male at the tips of branchlets, female terminating side branchlets ; fruit globose, 0.25 inch in diam., bluish black, resinous : seeds 2–5 in each fruit, ovoid. This species has attained particular interest as it appears to connect the East Asian *J. chinensis* Linn. and the Western *J. excelsa* Bieb. (Dallimore & Jackson, 312).

Indian juniper occurs more or less gregariously in open crops ; it occurs also scattered on dry rocky or stony ground in regions of scanty rainfall. Only under favourable sheltered situations with a moderate amount of moisture in the soil does the juniper crop tend to become dense. The flowers appear in spring and fruits ripen in September October in the second year. Though some seed is produced every year, good seed-years occur at less frequent intervals. Seedlings appear naturally but the great majority of them perish, probably from drought. Heavy snowfall assists reproduction by increasing the moisture content of the soil.

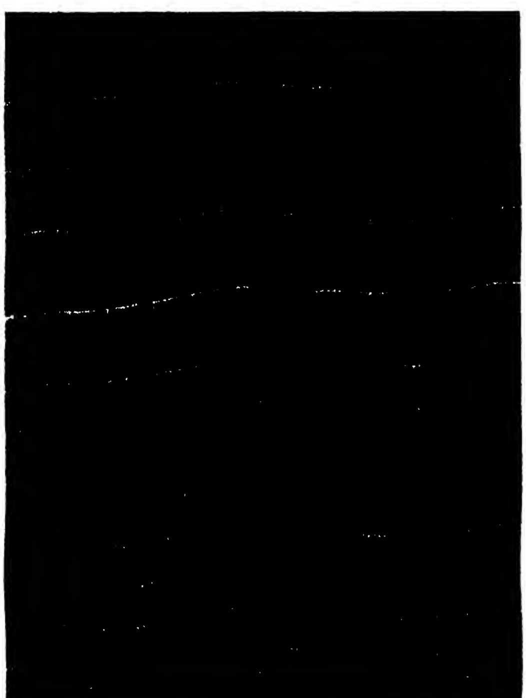
The tree has a strong spreading root system, particularly on dry rocky ground and is, therefore, windfirm, though it becomes gnarled and stunted in exposed situations. It is both drought and frost-hardy, enduring low temperatures. The rate of growth is slow ; the mean annual girth increment varies from under 0.1 to 0.3 in., and exceeds the latter figure

only under exceptionally favourable conditions. A tree may, therefore, be expected to attain a girth of 6 ft. in 240–720 years (Troup, III, 1163–66).

The tree suffers much by lopping and stripping of bark. The wood-rotting fungus, *Fomes juniperinus* (V. Schr.) Sacc. & Syd., is reported to affect it (Troup, III, 1165; Khan, *Pakist. J. Sci.*, 1952, **4**, 65).

The wood is dull red to reddish brown, often with a purplish cast, becoming brown after exposure. It is highly resinous and has a cedary odour and taste. It is moderately soft, light (sp. gr., *c.* 0.43 : wt., 28 lb./cu. ft.), straight-grained, fine- and even-textured. The timber seasons slowly but without warping or splitting. It is durable under cover. Clean timber is easy to saw though difficult to obtain; usually the timber is knotty and sawing is difficult. It works with great ease (Pearson & Brown, II, 1023–24).

The chief importance of the wood lies in its suitability for pencil making. For this purpose, it has been found to be the best among the Indian timbers tested. Supplies, however, are scanty. Transport of timber from the forests to the plains is difficult as commercial exploitation on an economic basis does not seem to be practicable (Pearson & Brown, II, 1024; Rehman & Ishaq, *Indian For. Leafl.*, No. 66, 1945).



*F.R.I., Dehra Dun. Photo: K. A. Chowdhury*

FIG. 159. JUNIPERUS MACROPODA—TRANSVERSE SECTION OF WOOD (×10)

The wood is used locally for house building, walking sticks, drinking cups, etc. It is used also as fuel and for making charcoal. Twigs are burnt as incense and the fumes are supposed to relieve delirious condition in fevers (Pearson & Brown, II, 1024; Kirt. & Basu, III, 2383).

The fruit possesses medicinal properties similar to those of *J. communis*. Dried fruits on steam-distillation yield a volatile oil which has been included in I.P.C., along with the oil from the fruits of *J. communis*, as Oil of Juniper. I.P.C. specifications for the oil are the following: sp. gr.$^{15°}$, 0.840–0.850 : $[\alpha]_D$, +13 to +18° ; and $n_D^{20°}$, 1.470–1.4805. The yield of oil varies with the source of the fruit (Tehri-Garhwal, 0.66; Kulu, 1.50; Chamba, 1.68%); a sample of oil obtained from Tehri-Garhwal had the following characteristics: sp. gr.$^{20°}$, 0.9006; $n$, 1.4733; $[\alpha]$, +44.5°. The oil distilled from fruits from three localities in Baluchistan (yields: 1.55, 1.10, 2.04%) had the following constants: $d^{20°}$, 0.8379, 0.8355, 0.8343; $n_D^{20°}$, 1.4674, 1.4680, 1.4610; and $[\alpha]_D^{20°}$, +12.56°, +10.69° and +18.18°, respectively. It contained pinene (60–70%), oxygenated compounds (30–35%) and a small amount of cadinene. The oil was used in India, during World War II, as a substitute for juniper oil. For use in gin flavouring, pinene which gives the oil a turpentine odour, must be removed (Kirt. & Basu, III, 2382; I.P.C., 183–84; *For. Res. India*, pt I, 1945–46, 82; 1947–48, 76; 1950–51, 94).

**J. recurva** Buch.-Ham. [including *J. squamata* Buch.-Ham. syn. *J. recurva* var. *squamata* Parl., Hook. f. (Fl. Br. Ind.)] WEEPING BLUE JUNIPER

D.E.P., IV, 555; Fl. Br. Ind., V, 647; Kirt. & Basu, Pl. 923.

WESTERN HIMALAYAS—*Phulu, thelu, bhedara, wetyar*; NEPAL—*Tupi*; SIKKIM—*Chukboo*.

A prostrate or decumbent shrub or a small tree of graceful, drooping habit, attaining a height of 30–40 ft., distributed almost throughout the temperate and alpine Himalayas and Assam at altitudes of 7,000–15,000 ft.; the procumbent type (*J. squamata*) the stems of which creep over ground, rooting freely and sending up numerous short, erect branches which form dense thickets, is more common in western Himalayas. Leaves awl-shaped, overlapping in whorls of three, 0.1–0.25 in. long, dull or greyish green; flowers monoecious or dioecious; fruit ovoid, 0.25–

0.35 in. long, dark brown or purplish black; seed solitary, ovoid.

The plant occurs gregariously, often extending over large areas, pure or mixed with *J. communis*. The procumbent type (*J. squamata*) can be grown in the plains. It is propagated by nursery seedlings raised from cuttings of prostrate stems and planted out early in the rainy season (Troup, III, 1166 67).

The wood is light red, moderately hard and heavy (wt., 35-47 lb./cu. ft.), fragrant and resinous; it is locally used as fuel. It is suitable for use as pencil wood. In Burma, it is used as coffin wood. The wood, leaves and twigs are used as incense and for this purpose, they are sometimes imported from Sikkim: the smoke from green wood is reported to be emetic. The fruits yield (0.46 0.88%) an essential oil, having the following characteristics: sp. gr.$^{20°}$, 0.9266; $n$, 1.4812; and $[\alpha]$, +32.5° (Gamble, 698; Trotter, 1944, 217; Rodger, 6; Kirt. & Basu, III, 2382; *For. Res. India*, pt I, 1947-48, 76; 1950-51, 94).

*J. wallichiana* Hook. f. syn. *J. pseudosabina* Hook. f. (Fl. Br. Ind.), non Fisch. & Mey. (BLACK JUNIPER: HINDI *Bhil*; SIKKIM– *Tchokpo*) is a robust shrub or a tree, up to 60 ft. high, found in the Himalayas from Kashmir to Bhutan at altitudes of 9,000-15,000 ft. The wood of the species is similar to that of *J. macropoda*. The leaves and twigs are sold as incense in Darjeeling; they are also insect-repellent. The bark, which exfoliates in long fibrous strips, is reported to be used locally as pads and for other domestic purposes [Biswas, *Manufacturer*, 1950-51, **2** (1), 6].

Among the exotic species of *Juniperus* introduced into India, *J. virginiana* Linn. (RED CEDAR, PENCIL CEDAR) is perhaps the most important. It is a sturdy ornamental tree, native of North America, and is propagated by seeds or cuttings. The wood is pink or reddish, fragrant, rather soft, brittle, straight-grained and very durable. It is the most valuable of all known woods for pencil making.

The wood on steam-distillation yields 1-3% of a volatile oil, known in the trade as Cedarwood Oil. The yield of oil depends upon the proportion of heartwood to sapwood in the material used for distillation: heartwood contains up to 4% of oil while sapwood contains less than 1%. Commercial cedarwood oil is derived chiefly from chips and sawdust obtained from the processing of wood for various uses. Cedarwood oil is a colourless or pale yellow liquid with a soft balsamic fragrance characteristic of the wood. It has the following constants: sp. gr.$^{15°}$, 0.943-0.964; $[\alpha]_D$, −18° to −42°; $n_D^{20°}$, 1.50-1.51; acid val., up to 1.5; ester val., up to 12; ester val. after acetylation, 26-28; and solubility in 90% alcohol, 1 in 10-20 vol. or in 95% alcohol, 1 in 7 vol. The oil contains cedrene isomers (80%), cedrol (3-14%), small amounts of cedrenol and pseudocedrenol, and bicyclic sesquiterpenes (Wise & Jahn, I, 579; Guenther, VI, 355-64).

Cedarwood oil is used in insecticides, perfumery, soaps, liniments, cleaning and polishing preparations, and as an adulterant of sandalwood and geranium oils. It is used also in microscopy. It has been used as an abortifacient, but in some cases death has been caused by its use (Hill, 190; U.S.D., 1955, 1728; Panshin *et al.*, 509).

The residue from the still after steam-distillation for oil, is used for horticultural purposes as a substitute for coconut fibre refuse. It is also used in the manufacture of linoleum. The wood, twigs and fruits are burnt as incense. The leaves were formerly used

*F.R.I., Dehra Dun. Photo: R. P. Bahuguna*

FIG. 160. JUNIPERUS PROCERA

as an ingredient of a counter-irritant ointment. Small excrescences, sometimes found on the branches of the tree and known popularly as Cedar Apples, are used as an anthelmintic (Dallimore & Jackson, 335; Krishnamurthi, 216; U.S.D., 1955, 1728).

*J. procera* Hochst. (EAST AFRICAN CEDAR) is a native of East Africa introduced into India. It attains a height of about 100 ft. in some places in the Nilgiris. The wood (wt., 30–40 lb./cu. ft.) is reddish brown, soft and fragrant with a fine and even grain except in wood from old trees. The wood works and polishes well, but is rather brittle. It is durable, resistant to damp and insect attacks and is useful for building purposes, furniture, cabinet making and for pencils. An oil similar to cedarwood oil is obtained by the steam-distillation of the wood. The residue from the distillation still is suitable for the manufacture of hard boards (Krishnamurthi, 216; Titmuss, 41; Dallimore & Jackson, 320; Packman, *Colon. Pl. Anim. Prod.*, 1955, **5,** 137; Parry, *E. Afr. agric. J.*, 1953–54, **19,** 89).

*J. bermudiana* Linn. (BERMUDA CEDAR) is a tree, 40–50 ft. in height, native of Bermudas. The wood is red in colour, sometimes with pretty markings, and is very durable. It is used for shipbuilding, furniture and cabinet work (Dallimore & Jackson, 295).

*J. chinensis* Linn. (CHINESE JUNIPER), a native of China and Japan, is a very variable tree, sometimes exceeding 60 ft. in height. It is usually pyramidal or columnar in form and is grown for decorative purposes. The wood is durable but too scarce to be of commercial importance. It is used for preparing cosmetics and as incense in China. It yields an oil resembling that of *J. virginiana* (Dallimore & Jackson, 300; Burkill, II, 1272).

## JURINEA Cass. (*Compositae*)

A genus of herbs and undershrubs distributed from Central Europe and the Mediterranean region eastwards to China. Two species occur in India.

### J. macrocephala Benth.

D.E.P., IV, 556; Fl. Br. Ind., III, 378; Kirt. & Basu, Pl. 552.

PUNJAB & NORTH WESTERN HIMALAYAS **Dhup, gugal.*

A perennial herb, without aerial stem, found in the Himalayas from Kashmir to Kumaon at altitudes of 10,000–14,000 ft. Root woody, aromatic, perennial; leaves radical, 6–18 in. × 1.5–7 in., cottony above, thickly white-tomentose beneath, pinnately divided into broad, lobulate, toothed segments; flowerheads 3–30, purple, sessile or shortly peduncled; achenes grey, flattened, curved, 4–5 angled, tubercled, with copious pappus.

The aromatic roots are used as incense in houses, temples and religious ceremonies; they are reported to form the chief ingredient of *dhup* available in North Indian bazaars. The roots are considered to be stimulant and given in fever after child birth. A decoction of the roots is given in colic. Bruised roots are applied to eruptions. The roots are collected in summer and autumn and sent to the plains for marketing; some quantity is exported to Tibet (Kaul, 21).

* These names are applied to a number of fragrant plant products used as incense and fumigants.

## JUSSIAEA Linn. (*Onagraceae*)

A genus of herbs or undershrubs often growing in water or marshy places and distributed in the tropics and subtropics of the world, chiefly in America. Three species occur in India.

### J. repens Linn.

Fl. Br. Ind., II, 587.

BENG.—*Kesara-dam.*

BIHAR—*Dhabni, kesariba.*

A succulent, creeping or floating herb, occurring throughout the plains of India in ponds and marshes and on river banks; when floating the stems are supported by spongy vesicles (0.5–1.5 in. long) situated below leaf bases. Leaves alternate, obovate or oblanceolate; flowers white, solitary, axillary; capsule woody, linear cylindric (0.5–1.5 in. long); seeds numerous.

The herb is used as a paste or in poultices for ulcers and skin complaints (Bressers, 65; Burkill, II, 1273).

### J. suffruticosa Linn.; C.B. Clarke (Fl. Br. Ind.) in part.

D.E.P., IV, 556; Fl. Br. Ind., II, 587; Kirt. & Basu, Pl. 436.

SANS.—*Bhulavanga*; HINDI—*Banlunga*; BENG.—*Banlung, lalbunlunga*; MAR.—*Panalavanga*; TEL.—*Niruyagni-vendramu*; TAM.—*Kattukkirambu, kirambuppundu, ninkkirambu*; KAN.—*Kavakula*; MAL.—*Kattuthumba, kattukkaryampu*; ORIYA—*Bilolobongo.*

An erect, much-branched, suffruticose perennial, up to 8 ft. high, occurring throughout the greater part of India, usually in wet and moist places in the plains. Leaves alternate, nearly sessile, very variable, linear to broadly elliptic, more or less woolly;

flowers yellow, tetramerous, solitary, axillary; capsule sub-quadrangular (1–2 in. long), clove-like in appearance, membranous; seeds numerous, minute, ovoid, didymous, shining. The species as described in Fl. Br. Ind. is very variable and is considered by many authors to comprise more than one species; it is, however, not possible to discriminate between them on the basis of their economic uses.

The plant is considered astringent, carminative, laxative, diuretic and anthelmintic. A decoction of the plant is given for flatulence, dropsy, leucorrhoea and spitting of blood; it is used also in diarrhoea and dysentery. A decoction of the root is given in fever. The leaves are mucilaginous and used in Malaya for poulticing in headaches, orchitis, glands in the neck and nervous diseases. A kind of tea is also made from the leaves. In Africa, the plant enters into prescriptions for rheumatic pains (Kirt. & Basu, II, 1089; Burkill, II, 1274; Bressers, 66; Dalziel, 42).

*J. tenella* Burm. f. syn. *J. linifolia* Vahl; *J. fissendocarpa* Haines is a much-branched undershrub, 3–4 ft. high, with subsessile, linear-lanceolate leaves, occurring in watery and swampy places in Bihar and Orissa and in some parts of South India. The plant is reported to be common in rice fields in Malaya and is ploughed in, along with other plants, as green manure. An infusion of the root is given for syphilis. In Celebes, the plant is employed in poultices for pimples and in Philippines for the preparation of a black dye (Burkill, II, 1273; Brown, II, 403).

**JUSTICIA** Linn. (*Acanthaceae*)

A large genus of herbs or shrubs distributed in the tropical regions of the world. About 50 species are recorded in India.

**J. betonica** Linn.

Fl. Br. Ind., IV, 525.

TEL.—*Tellarantu*; TAM.—*Velimungil*; MAL.—*Vellakurunji, venkurinni.*

MADHYA PRADESH—*Mokandar*; BIHAR—*Had-pat.*

An erect shrub, 2–4 ft. high, found almost throughout India in rocky ravines, waste lands and hedges. Leaves 2–4 in. long, ovate-lanceolate; flowers small, white with rose or pink markings, in simple or branched terminal spikes.

The plant is used as an application for swellings; it is also used in diarrhoea. In Ceylon, the leaves are used as poultice for boils (Burkill, II, 1274; Haines, IV, 691; Macmillan, 365).

**J. gendarussa** Burm. f. syn. *Gendarussa vulgaris* Nees

D.E.P., IV, 557; Fl. Br. Ind., IV, 532; Kirt. & Basu, Pl. 724.

HINDI—*Udisanbhalu, nilinargandi*; BENG.—*Jagatmadan*; MAR.—*Bakas, kala adulsa, tao*; TEL.—*Addasaramu, gandharasamu, nallanochili, nelavavili*; TAM.—*Karunochchi, vadaikkuthi*; KAN.—*Aduthoda gida, karinekki, natchu kaddi*; MAL.—*Karinochil, vatankolli*; ORIYA—*Kukurodonti.*

ASSAM—*Tita-bahak, bishalya-karani*; GARO—*Dajagipe*; MIKIR—*Titiria-sosoarong.*

An evergreen scented shrub, 2–4 ft. high, found throughout the greater part of India and Andaman Islands. Leaves 2.5–5.0 in. long, lanceolate or linear-lanceolate, glabrous; flowers small, white with pink or purple spots inside, in terminal or axillary spikes; capsules 0.5 in. long, clavate, glabrous, containing 4 seeds.

*J. gendarussa* is considered to be a native of China. It is frequently grown in Indian gardens as a hedge or border plant; it is sometimes found as an escape. It is propagated by cuttings and grows quickly. It is hardy, withstands heavy rainfall and thrives in shade (Duthie, II, 210; Gopalaswamiengar, 182, 188).

The plant is considered febrifuge, emetic, emmenagogue and diaphoretic. In Malaya, it is used for the treatment of lunacy, debility and snake bite; it is also given for amenorrhoea and stomach troubles. The leaves are used as antiperiodic, alterative and insecticide. Fresh leaves are used topically in oedema of beriberi and rheumatism. Leaves and tender shoots are considered diaphoretic and an infusion of the leaves is given internally in cephalalgia, hemiplegia and facial paralysis. The juice of leaves is reported to possess the property of stopping internal haemorrhage; it is dropped into the ear for earache and into the nostril for hemicrania; it is used also for colic in children. The root is also reported to have several medicinal uses. The bark is considered emetic [Kirt. & Basu, III, 1897; *J. sci. Res. Indonesia*, 1952, **1** (suppl.), 30; Burkill, I, 1066; Nadkarni, I, 572; Quisumbing, 889–90; Biswas, *Manufacturer*, 1950–51, **2** (1), 6].

The leaves contain a bitter and slightly toxic alkaloid. A decoction or alcoholic extract of the roots produced slight paralysis in rats in doses of 1–2 g./kg. body wt.; in doses of 10–20 g./kg. it is antipyretic and depressant producing violent diarrhoea and eventually death (Wehmer, II, 1143; *Chem. Abstr.*, 1937, **31**, 2688).

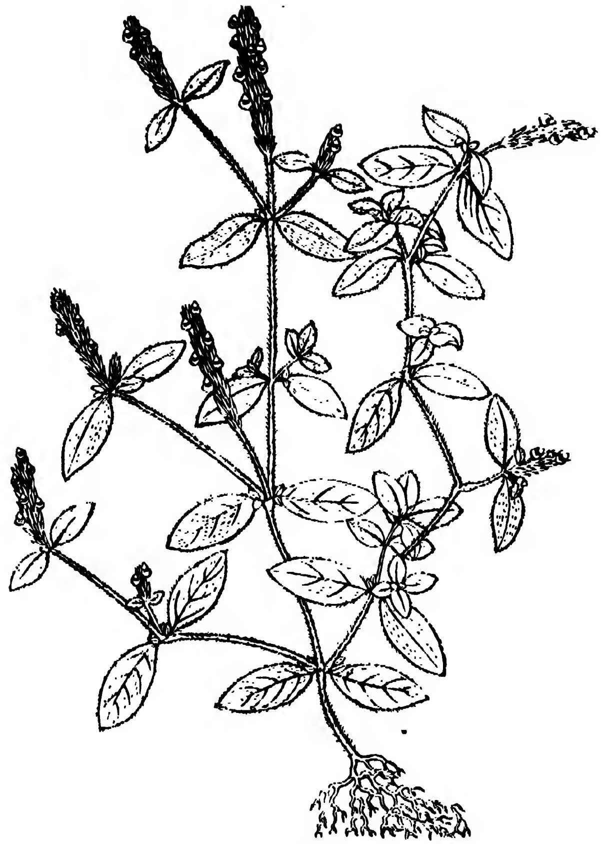


FIG. 161. JUSTICIA PROCUMBENS—FLOWERING PLANT

**J. procumbens** Linn.

D.E.P., IV, 557; Fl. Br. Ind., IV, 539.

MAR.—*Karambal, kalmashi*; TAM.—*Ottu pillu, poom-pillu, palkodi, nerei-poottie.*

BOMBAY—*Ghati-pitpapra, pitpapada.*

A procumbent, diffuse, slender, branching annual, 4–16 in. high, distributed in Bihar, Aravalli hills (Rajasthan), Deccan, western ghats from Pulney southwards, and west coast from Konkan to Kerala: the plant is usually found in moist places and is particularly abundant in the rainy season. Leaves elliptic or lanceolate; flowers pale purple, in dense, cylindrical terminal spikes; capsules oblong, shortly pointed, pubescent at the tip; seeds finely tuberculate.

The plant is said to be eaten in some parts of Bombay. The dried plant possesses a somewhat bitter disagreeable taste and is used as a substitute for true *Pit-papra* obtained from *Fumaria vaillantii* Loisel. It is considered laxative, diaphoretic, diuretic, alterative, expectorant, anthelmintic and febrifuge. The juice of the leaves is squeezed into the eye in cases of ophthalmia. An infusion of the herb is given in asthma, cough, rheumatism, backache, plethora, flatulence and lumbago. A decoction of leaves is sometimes used in the treatment of curvature and diseases of the bone. The Mundas are reported to use the herb for the treatment of wounds in buffaloes (Chopra, 501; Nadkarni, I, 715; Kirt. & Basu, III, 1898; Quisumbing, 891; Cheo, *Bot. Bull. Acad. sinica*, 1947, **1**, 307; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 1284; Bressers, 112).

*J. diffusa* Willd. = *J. purpurea* Linn., approaching var. *vahlii* C.B. Clarke, is a tall, straggling, narrow-leaved herb, found in Ranchi (Bihar), Circars and Deccan. The root of the plant is used by the Mundas as a remedy for madness. *J. quinqueangularis* Koenig, a prostrate or ascending herb, 1–1½ ft. high, is found almost throughout India. The leaves of the plant are eaten as pot-herb. *J. simplex* D. Don (DELHI—*Onga*) is an erect, slender herb, found throughout India ascending to 7,000 ft. in the Himalayas. *J. tranquebariensis* Linn. f. (TAM.—*Sivanarvembu*) is a low undershrub, found in Deccan, Carnatic and from Mysore southwards. The juice of the leaves is considered cooling and aperient; it is given for small-pox in children. Bruised leaves are applied to contusions. *J. vasculosa* Wall. is a small herb found in E. Himalayas, Sibsagar (Assam) and Khasi hills at altitudes of 2,000–5,000 ft. The leaves of the herb are used for inflammations (Bressers, 112; Fl. Madras, 1081; Fl. Delhi, 277; Nadkarni, I, 715; Fl. Assam, III, 454).

**Jute** — *see* **Corchorus**

**Jute, American** — *see* **Abutilon**

**Jute, Bimlipatam** — *see* **Hibiscus**

# K

**Kabuli Gram** — *see* **Cicer**

**Kachi Grass** — *see* **Cymbopogon**

**Kadam** — *see* **Anthocephalus**

**Kadiya Gum** — *see* **Sterculia**

**KADSURA** Kaempf. ex Juss. (*Magnoliaceae*)

Fl. Br. Ind., I. 45.

A genus of evergreen twining shrubs distributed in southern and eastern Asia. Three species occur in India.

*K. heteroclita* (Roxb.) Craib syn. *K. roxburghiana* Arn.; *K. wightiana* Arn. (Eastern Himalayas—*Pattiamlo, salado-rik*; Assam—*Kang-mari, mi-jangew, theiarbawm*) is a stout scandent shrub occurring in eastern Himalayas, Assam and western ghats in Malabar ascending to an altitude of 8,000 ft.: it has also been recorded from Andaman Islands. Leaves broadly ovate to ovate-lanceolate, rather fleshy; flowers whitish, solitary, axillary; fruit red, globose (1–2 in. diam.) consisting of more or less coalescent, fleshy carpels: seeds orbicular, compressed, edible. The fruit is sometimes eaten (Gamble, 14; Cowan & Cowan, 11).

**KAEMPFERIA** Linn. (*Zingiberaceae*)

A genus of rhizomatous herbs, distributed in the tropics and subtropics of Asia and Africa. About 10 species occur in India; a few exotics are grown for ornament.

Kaempferias are grown in gardens for their handsome flowers and foliage. The flowers are borne close to the ground and plants are usually grown in pots. Propagation is by divisions of the rhizome which may be potted in light soil; liquid manure is applied to promote growth. Repotting becomes necessary once in two years (Gopalaswamiengar, 494).

**K. galanga** Linn.

D.E.P., IV, 561; Fl. Br. Ind., VI, 219; Kirt. & Basu, Pl. 938.

Sans.—*Chandramulika, sugandhavacha*; Hindi—*Chandramula*; Beng.—*Chandumula*; Mar.—*Kachri, kapur-kachri*; Tel.—*Kachoram*; Tam.—*Kacholam, kacholakilangu*; Kan.—*Kachchura*; Mal.—*Katjulam, kacholam*.

A small, handsome herb found throughout the plains of India and cultivated for ornament and for its aromatic rhizome. Leaves two or three, spreading flat on the ground, rotund-ovate or suborbicular (2.5–6.0 in. × 1.75–4.0 in.): petioles short, channelled; flowers white, 6–12 on a short scape, fugacious, opening successively: lip bilobed with lilac or purple spots.

The tuberous rhizomes possess a camphoraceous odour with a somewhat bitter aromatic taste, resembling that of the rhizomes of *Hedychium spicatum*. Steam-distillation of triturated rhizomes gave 2.4–3.88% (on dry wt.) of a volatile oil. The oil freed from ethyl *p*-methoxycinnamate, which separates out on cooling the distillate, had the following constants: sp. gr.$_{30°}^{30°}$, 0.8792–0.8914; $[\alpha]_D^{30°}$, $-2.6°$ to $-4.5°$; $n_D^{30°}$, 1.4773–1.4855; acid val., 0.5–1.3; sap. val., 99.7–109.0; and sap. val. after acetylation, 110.1–116.3. The following compounds have been reported to be present in the oil: *n*-pentadecane, ethyl *p*-methoxycinnamate (30%), ethyl cinnamate, *l*-$\Delta^3$-carene, camphene, borneol and *p*-methoxystyrene (probably formed during the distillation). The oil is not produced on a commercial scale (Guenther, V, 130; Panicker *et al.*, *J. Indian Inst. Sci.*, 1926, **9A**, 133; Hariharan & Sudborough, ibid., 1925, **8A**, 189).

The herb is used as a flavouring for rice. Rhizomes and leaves are employed as a perfume in hair washes, powders and other cosmetics. They are worn by women for fragrance and also used for protecting clothes against insects; they are eaten along with betel and arecanuts as a masticatory (Burkill, II, 1276; Quisumbing, 193).

The rhizomes are considered stimulating, expectorant, carminative and diuretic. They are used in the preparation of gargles; they are administered with honey in coughs and pectoral affections. In Philippines, a decoction of the rhizomes is used for dyspepsia, headache and malaria. Boiled in oil, the rhizomes are applied externally to remove nasal obstructions. Roasted rhizomes are applied hot in rheumatism and for hastening the ripening of inflammatory tumours. They are also used as a wash in dandruff and for relieving irritation produced by stinging caterpillars. Mixed with oil, the rhizomes are used as a cicatrizant. In Malaya, they are used for chills in elephants. The juice of the

plant is an ingredient of some tonic preparations. The leaves are used in lotions and poultices for sore eyes, sore throat, swellings, rheumatism and fevers (Chopra, 501; Kirt. & Basu, IV, 2427; Burkill, II, 1276; Quisumbing, 193–94; Brown, 1941, I, 430).

**K. rotunda** Linn.

D.E.P., IV, 561; Fl. Br. Ind., VI, 222; Kirt. & Basu, Pl. 940.

SANS.—*Bhuchampaca, bhumichampa;* HINDI, BENG. & MAR.—*Bhuichampa;* GUJ.—*Bhuichampo;* TEL.—*Bhuchampakamu;* TAM.—*Kondakalava, nerpichan;* KAN.—*Nelasampige;* MAL.—*Chenchineerkilangu, malankua.*

A handsome, aromatic herb with a tuberous rhizome, distributed throughout India and cultivated for ornament. Leaves two, erect, oblong or ovate-lanceolate, up to 18 in. × 4.5 in.; flowers fragrant, white, borne in a crowded spike, opening successively; lip purple or lilac.

The underground portion of the plant consists of a sub-globose tuberous rhizome from which branch off fleshy rootlets bearing small oblong or rounded tubers; the rhizomes and tubers have a bitter, pungent, camphoraceous taste. On steam-distillation the rhizomes yield 0.2% of a light yellow volatile oil (sp. gr.$^{16°}$, 0.890–0.900; $[\alpha]$, +12°) with an unpleasant odour, at first camphoraceous and later resembling the odour of tarragon oil (from *Artemisia dracunculus* Linn.). The oil contains cineol and probably methyl chavicol. The rhizomes and young leaves are used as a flavouring; rhizomes are also used in cosmetics. Tubers are used as a dye (Gildemeister & Hoffmann, II, 276; Parry, I, 107; Quisumbing, 193; Mooney, 204).

The tubers of the plant are widely used as a local application for tumours, swellings and wounds. They are also considered stomachic and given in gastric complaints; they help to remove blood clots and other purpulent matter in the body. The juice of the tubers is given in dropsical affections of hands and feet, and of effusions in joints; it is also considered efficacious in resolving phlegm. The juice, however, causes salivation and vomiting. The herb is used in ointments for wounds (Kirt. & Basu, IV, 2428).

*K. angustifolia* Rosc. (HINDI & BENG.—*Kanjanbura, mudunirbisha*) is a herb with a tuberous rhizome occurring at the foot of eastern Himalayas and in north Bengal. It is used in veterinary practice (Chopra, 501).

**Kafir Plum** — *see* **Harpephyllum**

**KALANCHOE** Adans. (*Crassulaceae*)

A genus of succulent herbs or robust undershrubs, distributed in the tropics of the Old World, particularly in Africa and Madagascar. About 11 species are recorded from India.

Many *Kalanchoe* species are grown in India for their ornamental foliage and flowers. They prefer dry, rocky or sandy localities and are useful in gardens as border and pot plants and in rockeries. They are easily propagated by seeds or cuttings (Firminger, 529; Gopalaswamiengar, 175, 399).

**K. integra** (Medic.) Kuntze syn. *K. spathulata* DC.; *K. brasiliensis* Cambess.

D.E.P., IV, 564; Fl. Br. Ind., II, 415; Fl. Malesiana, Ser. I, **4**(3), 201, Fig. 2.

HINDI—*Haiza, rungru, tatara.*

KUMAON—*Bakalpatta, patkuari;* NEPAL—*Hathokane.*

An erect, perennial succulent, 1–4 ft. high, with terete or quadrangular stem, found in the tropical Himalayas from Kashmir to Bhutan up to a height of 6,000 ft., on Lushai hills and in the Deccan. Leaves spathulate, obtuse, crenate, cuneate at the base; flowers yellow to red, in many flowered panicles.

*K. integra* is a very variable species and includes a number of forms, differing only slightly in taxonomic features, but assigned specific status. This species and *K. laciniata* (q.v.) are used in indigenous medicine in the same manner as *Bryophyllum* spp. The leaves are poisonous to goats and are not eaten by cattle. The expressed juice of the leaves of a bitter variety is antiperiodic, tonic and purgative. The leaves are reported to possess insecticidal properties; they are burnt and applied to abscesses (Kirt. & Basu, II, 1001; Chopra *et al.*, 437).

**K. laciniata** (Linn.) DC.

D.E.P., IV, 562; Fl. Br. Ind., II, 415; Kirt. & Basu, Pl. 406.

SANS., HINDI & BENG.—*Hamsagar;* TAM.—*Malakalli.*

BOMBAY—*Parnabij, zakhmhyat.*

An erect, stout, perennial herb distributed in the Deccan and hilly areas of S. India up to an elevation of 3,000 ft. Leaves large, very variable, succulent, deeply pinnatifid twice or thrice; flowers yellow orange or magenta, in paniculate cymes.

The plant is used in indigenous medicine in the same way as *Bryophyllum* spp. The leaves are considered styptic, astringent and antiseptic. Roasted or

crushed leaves are applied in poultices to wounds, cuts, abrasions, ulcers, bites of venomous insects, gnats, etc. Internally the leaf juice is given in diarrhoea, dysentery, lithiasis and phthisis. In Malaya, leaves are used as poultice for coughs and colds; they are used in lotions for small pox (Nadkarni, I, 717; Burkill, II, 1277; Quisumbing, 351-52).

**Kalanchoe pinnata** — *see* **Bryophyllum**

**Kale** — *see* **Brassica**

**Kalmegh** — *see* **Andrographis**

**Kamala** — *see* **Mallotus**

**KANDELIA** Wight & Arn. (*Rhizophoraceae*)

A monotypic genus of trees distributed in south-east Asia.

**K. candel** (Linn.) Druce syn. *K. rheedii* Wight & Arn.

D.E.P., IV, 565; Fl. Br. Ind., II, 437; Kirt. & Basu, Pl. 410.

Beng.—*Goria*; Tel.—*Kandigala*; Tam.—*Thuvar kandan*; Kan.—*Kandale*; Mal.—*Cerukandal*; Oriya—*Rasunia*.

An evergreen shrub or a small tree with spongy, reddish brown, flaky bark, found in the coastal forests of India, usually in muddy swamps and tidal creeks. Leaves opposite, oblong, 2–4 in. × 1–2 in., entire, obtuse, dark green above and reddish brown beneath; flowers large, white, in axillary dichotomous cymes; fruit ovoid, 0.5-1.0 in. long, surrounded by reflexed calyx, indehiscent, 1-celled, 1-seeded.

The tree is recommended for planting along the sides of backwaters for green manure purposes. The bark of the tree is rich in tannins and is suitable for heavy leather tannage; bole bark contains (av.): 17.3% tannin and 13.5% non-tans; twig bark contains: 15.4% tannin and 9.2% non-tans. The bark may also be used for dyeing; it produces red and brown colours. The bark is reported to be used, along with dried ginger or long pepper and rose water, for diabetes; it has been shown, however, that aqueous or alcoholic extracts of the bark do not have any effect on the blood sugar of normal or alloxan-diabetic rabbits [Mudaliar & Kamath, *J. Bombay nat. Hist. Soc.*, 1954-55, **52**, 69; Rahim, *Tanner*, 1954–55, **9**(9), 15; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, **1**(2), 86, 88; Perkin & Everest, 632; Kirt. & Basu, II, 1013; Mukerji, *J. sci. industr. Res.*, 1957, **16A**(10), suppl., 16].

The wood (wt., 35–40 lb./cu. ft.) is reddish brown, soft and close-grained. It is used as fuel and for making charcoal. It is reported to contain 0.23–0.26% silica, chiefly in the rays (Gamble, 334; Talbot, II, 6; Troup, II, 503; Amos, *Bull. sci. industr. Res. Org., Melbourne*, No. 267, 1952, 48).

**Kaolin** — *see* **Clays**

**Kapok** — *see* **Ceiba**

**Kapok, Indian** — *see* **Salmalia**

**Kaporie Tea** — *see* **Epilobium**

**Karaunda** — *see* **Carissa**

**Karaya Gum** — *see* **Sterculia**

**Karen Potato** — *see* **Dioscorea**

**Karen Wood** — *see* **Heterophragma**

**Kashmir Stag** — *see* **Deer**

**Kateri-Indrayan** — *see* **Ecballium**

**Katha** — *see* **Acacia**

**Katira Gum** — *see* **Cochlospermum**

**KAYEA** Wall. (*Guttiferae*)

A genus of trees distributed in south-east Asia. Three species occur in India.

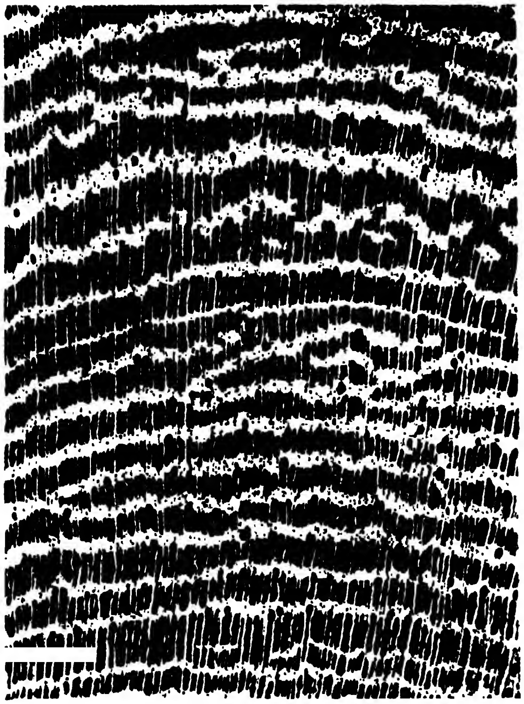
**K. assamica** King & Prain

Fl. Assam, I, 113.

Lakhimpur—*Sia-nahor*.

A handsome evergreen tree, up to 75 ft. in height, with a cylindrical bole, *c.* 40 ft. long and 6–8 ft. in girth, found gregariously in the sub-montane forests of north Lakhimpur. Bark light brownish grey, often exfoliating in large square plates; leaves opposite, ovate or elliptic-lanceolate, 3.0–5.5 in. × 1.0–1.8 in., coriaceous; flowers white, in terminal or axillary panicles; fruit depressed globose, 1.0 in. × 1.8 in., almost entirely enveloped by the accrescent hard sepals; seed solitary with flushing cotyledons.

The wood is light red to reddish brown, somewhat lustrous, interlocked-grained and fine-textured. It is heavy (sp. gr., *c.* 0.91; wt., 55–60 lb./cu. ft.) and considerably more elastic, stronger and harder than teak. The wood is liable to develop surface cracks; air seasoning of green converted sleepers and planks has given good results. It is moderately durable under cover, but untreated wood does not last long in exposed situations or under water; graveyard



F.R.I., Dehra Dun. Photo: K. A. Chowdhury

FIG. 162. KAYEA ASSAMICA—TRANSVERSE SECTION OF WOOD (×10)

tests at Dehra Dun gave an average life of 5-7 years. The wood is refractory to preservative treatment. It is not easy to work, but planes to a smooth surface (Pearson & Brown, I, 55-57 : Purushotham *et al.*, *Indian For.*, 1953, **79**, 49, Fig. 2/4).

The timber is much valued for house construction ; it is suitable for internal posts, beams and rafters ; it should produce very serviceable sleepers if treated. The fruit is used as fish poison (Pearson & Brown, I, 57 : Bor, 202).

**K. floribunda** Wall.

Fl. Br. Ind., I, 276.

Assam—*Bolong, phai-hershei, karal.*

A tall evergreen tree with greenish grey or brown bark exfoliating in round scales, found in eastern Himalayas and hills of Assam up to an altitude of 3,000 ft. Leaves opposite, narrowly oblong to lanceolate, 5-10 in. × 1-2.5 in., coriaceous ; flowers white with rosy edges, in terminal panicles ; fruit depressed globose, 1.5-1.75 in. diam., indehiscent, almost completely enclosed in hardened calyx, 1-seeded.

The wood of this species is heavy with rather large but distant pores. The data for its comparative suitability as timber expressed as percentages of the same properties of teak, are: weight, 120 ; strength as a beam, 105 ; stiffness as a beam, 100 ; suitability as a post, 95 ; shock-resisting ability, 155 ; retention of shape, 50 ; shear, 125 ; and hardness, 145. The wood is not very durable ; graveyard tests at Dehra Dun gave an average life of 2-5 years. It is used for dug-outs and construction purposes. It is also suitable for tool handles [Fl. Assam, I, 113 : Limaye, *Indian For. Rec., N. S., Util.*, 1944, **3**(5), 20 : *Indian For.*, 1952, **78**, 368 : Purushotham *et al.*, ibid., 1953, **79**, 49, Fig. 2/5].

**KEDROSTIS** Medic. (*Cucurbitaceae*)

A genus of prostrate or scandent herbs, distributed chiefly in Africa. One species occurs in India.

**K. rostrata** (Rottl.) Cogn. syn. *Rhynchocarpa foetida* C.B. Clarke (Fl. Br. Ind.) in part, non Schrad.

D.E.P., VI (1), 502 : Fl. Br. Ind., II, 627 : Kirt. & Basu, Pl. 467A.

Tel.—*Kukumadunda* ; Tam.—*Appakovay*.

Bombay—*Nurakvel.*

A scandent, monoecious herb with perennial root, occurring in the Deccan Peninsula. Stems angled, sparsely hairy ; tendrils simple, filiform ; leaves orbicular or reniform, sometimes 5-angled, cordate, entire or distantly toothed, membranous ; male flowers pale yellow, 2-4 at the apex of peduncles, female flowers solitary, rarely aggregated ; fruit a deep red ovoid berry, c. 1 in. long, beaked ; seeds few, ovoid.

The root is light grey, almost odourless with a sweet mucilaginous taste. It is demulcent and used in piles and asthma. Fruit and leaves are eaten (Kirt. & Basu, II, 1165).

**Kei-Apple** — *see* **Dovyalis**

**Kelp** — *see* **Algae**

**Kenaf** — *see* **Hibiscus**

**Kenari-Nut Tree** — *see* **Canarium**

**Keora** — *see* **Pandanus, Sonneratia**

**KERRIA** DC. (*Rosaceae*)

Bailey, 1947, II, 1736.

A monotypic genus, comprising *Kerria japonica* (Linn.) DC. (Japanese Rose), native of Japan, cultivated in Indian gardens for ornament.

*K. japonica* is a handsome deciduous shrub, 4-6 ft. high, with slender branches and bright green foliage. Leaves large, serrate ; flowers abundant, yellow, 1-2 inches in diameter, solitary, terminal. Horticultural

forms with double flowers and variegated leaves are known. The plant is propagated by cuttings, layers and root division; it grows in any good garden soil and though it endures sunlight it is best grown under partial shade; it thrives rather indifferently in India (Bailey, 1947, II, 1736; Firminger, 635; Parker, 230).

The leaves and roots of the plant contain small amounts (0.002%) of hydrocyanic acid. The tender leaves constitute a rich source of ascorbic acid (200 mg./100 g.) (Wehmer, I, 438; *Chem. Abstr.*, 1951, **45,** 8087).

**Khat** — *see* **Catha**

**Khas-khas** — *see* **Vetiveria**

**KICKXIA** Dum. (*Scrophulariaceae*)

D.E.P., IV, 642; Fl. Br. Ind., IV, 251; Kirt. & Basu, Pl. 692.

A small genus of herbs found in the region extending from Spain and north-west Africa to Afghanistan and India. Two species have been recorded in India.

*K. ramosissima* (Wall.) Janchen syn. *Linaria ramosissima* Wall. (Guj.—*Bhintgalodi, kanodi*) is a perennial herb with numerous filiform branches, membranous leaves and yellow flowers. It is found throughout India on walls, rocky and stony places, ascending to 7,000 ft. in the Himalayas. It is reported to be used as a remedy for diabetes (Pennell, 59; Santapau, *J. Bombay nat. Hist. Soc.*, 1950–51, **49,** 26; Kirt. & Basu, III, 1809).

*K. incana* (Wall.) Pennell syn. *Linaria cabulica* Benth.; *L. incana* Wall. is a perennial, found in central and western Himalayas, from Kashmir to Nepal up to 8,000 ft., Punjab, Bihar and Bombay. The herb is reported to be poisonous to man and livestock (Chopra *et al.*, 47).

**Kidney Bean** — *see* **Phaseolus**

**Kid Skins** — *see* **Fur and Fur-bearing Animals**

**KIGELIA** DC. (*Bignoniaceae*)

A small genus of trees native of Africa. One species has been introduced into India.

**K. pinnata** DC. COMMON SAUSAGE TREE

Haines, IV, 660; Benthall, 347.

A medium-sized spreading tree of rapid growth, with short trunk and long distorted branches, cultivated in many parts of India as an ornamental and roadside tree. The bark of the tree is greyish brown, rough; leaves imparipinnate: leaflets 7–9, elliptic-oblong or obovate, entire or serrate, 3–6 in. long; flowers deep chocolate-red, in long pendulous panicles; fruit gourd-like, up to 18 in. long × 5 in. diam., hanging by a rope-like penduncle up to 7 ft. long; seeds many, embedded in fibrous pulp. There is considerable difference of opinion regarding the identity and synonymy of the plant cultivated in India with *K. africana* Benth. and *K. aethiopica* Decne.

The plant thrives in deep open soils in cool situations, particularly on the margins of tanks, but becomes stunted where the subsoil is hard or infertile. It is easily propagated by seeds during rains. Vegetative propagation by cuttings has been attempted; hardwood cuttings, 9 in. long × 0.5 in. thick, treated with an aqueous solution (20 p.p.m.) of $\beta$-indolyl acetic acid for 12 hr., take root readily. Planting in pits, 40–50 ft. apart, has been suggested. The plant sheds its leaves twice during a year, but is never quite bare; heavy pruning is necessary to keep the tree straight (Cameron, 213; Firminger, 410; Colthurst, 95; Gamble, 517; Pratap Singh, *Sci. & Cult.*, 1955–56, **21,** 737).

FIG. 163. KIGELIA PINNATA—FLOWERING AND FRUITING BRANCHES

Analysis of the fruit gave the following values: moisture, 85.4; crude protein, 0.84; ether extr., 0.88; carbohydrates, 7.93; fibre, 4.29; and ash, 0.66%. The flowers contain an anthocyanin, cyanidin pentose-glycoside, and three flavones, including quercetin and kaempferol. The bark contains a bitter substance and tannic acid (*Chem. Abstr.*, 1935, **29,** 1887; Ponniah & Seshadri, *J. sci. industr. Res.*, 1953, **12B,** 605; Pankajamani & Seshadri, ibid., 1955, **14B,** 93; Wehmer, II, 1137).

The wood (wt., 44 lb./cu. ft.) is hard and of good quality, but long pieces are difficult to obtain. Roasted seeds of the plant are reported to be eaten in times of scarcity. The dry fruit may be used for the preparation of active carbon. The fruit is used in Africa as dressing for ulcers and for syphilis and rheumatism; it has purgative properties. The bark is used in rheumatism, dysentery and venereal diseases (Benthall, 347; Bhatia & Manohar Lal, *J. Indian chem. Soc. industr. Edn*, 1941, **4,** 236; Watt & Breyer-Brandwijk, 171; Quisumbing, 877).

## KINGIODENDRON Harms (*Leguminosae*)

A small genus of trees, distributed in parts of tropical Asia and the Pacific. One species occurs in India.

**K. pinnatum** (Roxb.) Harms syn. *Hardwickia pinnata* Roxb. Piney

D.E.P., IV, 201; Fl. Br. Ind., II, 270; Kirt. & Basu, Pl. 359.

Tam.—*Madayan samprani, kolavu, kodapalai*; Kan.—*Enne, yenne-mara*; Mal.—*Shurali, kiyavu, kodapalla.*

Coorg—*Choupaini, kolavu.*

A large, handsome, evergreen tree, attaining a height of 100 ft. and a girth of 14 ft., found in the forests of western ghats from South Kanara to Kerala. Bark dark brown or green, rather rough. leaves alternate, pinnate: leaflets 4–7, oblong-ovate, acute, 2–4 in. long; flowers small, white, in dense racemes arranged in panicles; pod obovoid-oblong, 1–2 in. long, nearly filled up by seed.

The sapwood is usually broad and of dirty whitish colour; heartwood purplish red to reddish brown, sometimes ornamental with fiddle-back mottling, generally blotched with oil exudations, broadly interlocked-grained and medium coarse-textured. It is strong, hard and heavy (sp. gr., 0.55–0.70; wt., 38–45 lb./cu. ft.). The timber is moderately refractory to seasoning; it may be stacked under cover and

*F.R.I., Dehra Dun. Photo: K. N. Tandon*

FIG. 164. KINGIODENDRON PINNATUM—TRANSVERSE SECTION OF WOOD (×10)

air-seasoned under favourable conditions after green conversion: kiln-seasoning of 1 in. thick boards has given good results. The sapwood is, however, liable to decay, discolouration and insect attack and should be discarded unless required for preservative treatment. The heartwood is fairly durable: the resin naturally present helps to protect it against adverse agencies. It is also said to be durable in contact with water (Pearson & Brown, I, 414–16; Trotter, 1944, 113).

The wood is not difficult to saw and work to a good lustrous surface. It also takes a high polish, but the resin tends to affect the finish after some time. It is suitable for turnery and perhaps also for rotary veneer work. The data for the comparative suitability of wood as timber, expressed as percentages of the same properties of teak, are: wt., 90; strength as a beam, 80; stiffness as a beam, 90; suitability as a post, 85; shock-resisting ability, 90; retention of shape, 65; shear, 100; and hardness, 85. The calorific value of the wood is: *sapwood*—5,113 cal., 9,204 B.t.u.; *heartwood*—5,087 cal., 9,156 B.t.u. [Pearson & Brown, I, 416; Trotter, 1944, 113; Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3**(5), 18; Krishna &

Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 18].

Piney is well known in South India and is primarily used on the west coast for beams, rafters, battens, ceiling boards, flooring and furniture. It has been used for cordite cases, bowls and croquet balls and is suitable for billiard tables and cue handles. Selected stock of the timber is used for cabinet work and ornamental veneers. It is reported to be used for ship-building and considered suitable for plywood (Pearson & Brown, I, 416; Trotter, 1944, 114; IS: 399-1952, 30; *Indian For.*, 1952, **78,** 274).

The tree yields, on tapping, a dark or reddish brown oleoresin (balsam), resembling Copaiba balsam (from *Copaifera* spp..) in odour and taste. The tapping is done by boring a hole, c. 3/4 inch in diam., in trees 5 ft. or more in girth. The hole which reaches the pith is placed 3 ft. above the ground and slopes downwards from the pith to the bark. A lip is fixed below the hole and the exudate is collected in a tin. When the flow ceases, the hole is plugged with a piece of wood. The tree is rested for about 10 years before tapping again. A healthy tree of 8 ft. girth yields about 12 gal. of the oleoresin; the maximum yield from a single tree has been reported to be 40 gal. Some trees yield a thin product, while others exude a viscous oleoresin; sometimes a tree is found which yields no oleoresin at all (Trotter, 1940, 289).

The following values were obtained for two specimens of the oleoresin: $d^{15}$, 1.008, 0.997; acid val., 90.2, 84.6; sap. val., 112.9, 103.7; acetyl val., 79.6, 83.0; volatile oil, 42.7%, 47.0%. It is inferior to copaiba balsam and does not appear to have any great commercial possibilities. It is used locally as wood varnish after thinning with turpentine; the varnish film, however, dries slowly and is decolourised by weathering. It is employed in the treatment of gonorrhoea. It has also been reported to be used as a dressing for sores of elephants (Iyer & Sudborough, *J. Indian Inst. Sci.*, 1919, **2,** 29; Kirt. & Basu, II, 882; Rama Rao, 142).

The oleoresin on steam-distillation yields a colourless volatile oil, the yield and composition of which vary according to the season of collection. The oil has a characteristic resinous odour and a pungent bitter taste. It has the following constants: $d^{15°}$, 0.931, 0.908; $d^{30.8°}$, 0.9045; $n^{20}$, 1.500, 1.500; $n^{30.8°}$, 1.4949; $[\alpha]_D$, $-1.72°$, $-7.86°$, $-9.4°$; acid val., trace, trace, nil; sap. val., nil; acetyl val., 12.6, 1.4, nil; and solubility in 95% alcohol, 1 in 5 vol. or more. The main constituent of the oil is $\beta$-caryophyllene (84%); $\alpha$-caryophyllene and a cadinene sesquiterpene (2%) are also present. The oil may be used as a substitute for imported clove oil [Gildemeister & Hoffmann, II, 601; Iyer & Sudborough, loc. cit.; Dev & Guha, *J. Indian chem. Soc.*, 1948, **25,** 495; 1949, **26,** 263; *Rep. ess. Oils Schimmel*, 1949–50, 12; Krishna & Badhwar, *J. sci. industr. Res.*, 1949, **8**(2), suppl., 156].

The resin left after the distillation of volatile oil is a hard, brittle mass, greenish yellow in thin layers and dark brown in lumps. It is almost completely soluble in alcohol (90%) and is suitable for preparing spirit or oil varnishes. It has the following characteristics: m.p., 53–56°; sp. gr., 1.088; acid val., 162.2; and sap. val., 193.9 (Iyer & Sudborough, loc. cit.).

**Kino** — *see* **Butea, Eucalyptus, Knema, Pterocarpus**

## KIRGANELIA Juss. (*Euphorbiaceae*)

A small genus of shrubs or small trees found throughout the tropics from Africa to China. One species occurs in India.

***K. reticulata** (Poir.) Baill. syn. *Phyllanthus reticulatus* Poir.

D.E.P., VI (1), 223; C.P., 887; Fl. Br. Ind., V, 288; Kirt. & Basu, Pl 857.

SANS.—*Krishna-kamboji*; HINDI—*Panjuli, makhi, buinowla*; BENG.—*Panjuli*; GUJ.—*Datwan*; MAR.—*Pavana*; TEL.—*Nallapuli, nallapurugudu, pandibarranlue, pulisar*; TAM.—*Abiranji, karunelli, karuppupilanji, nirppul, kattu-kilanelli*; KAN.—*Anamsule, chippulinellu, huli balli, karesuli, sannahogesoppu*; MAL.—*Kattuniruri, kilanelli, nirnelli*; ORIYA—*Jandaki*.

PUNJAB—*Panjuli*; DELHI—*Neelbari, makki*; RAJASTHAN—*Kabonan*; ASSAM—*Amluki*.

A large, straggling or sub-scandent shrub, 5–15 ft. high, occurring almost throughout tropical India, ascending to 5,000–6,000 ft. in Khasi and Jaintia hills, and in Andaman Islands. Leaves elliptic to oblong or obovate; flowers unisexual, axillary; male in fascicles of 2–6, female solitary; fruit fleshy, subglobose, 0.2 inch in diameter, purplish black when ripe; seeds 8–16, irregularly trigonous.

The plant is common on low moist ground along river banks, irrigation channels and waste places; sometimes it is found climbing among bushes. It

* According to Alston (Trimen's Flora of Ceylon, suppl., 1931, 259) the correct name of this plant is *Kirganelia lineata* (Willd.) Alston

forms an effective hedge along with other shrubs and flowers nearly throughout the year; it becomes more or less leafless between January and February (Brandis, 570; Haines, II, 129).

The leaves of the plant are considered diuretic and cooling. They contain tannic acid, but no alkaloid. The juice of the leaves is used with camphor and cubebs (*Piper cubeba*) for bleeding gums; it is also used for diarrhoea in infants. In E. Africa, powdered leaf is applied to sores, burns, suppurations and chafing of the skin. In Indo-China, the whole plant is used in the treatment of small pox and syphilis. The fruit is astringent and useful in inflammations and in diseases of the blood. A decoction of the root is given to children for coughs and catarrh and also for asthma. The bark has a faint sweetish taste and is considered alterative, attenuant, astringent and diuretic. In Ghana (Gold Coast), the juice from the stem is used for sore eyes (Kirt. & Basu, III, 2219–20; Dymock, Warden & Hooper, III, 265; Rama Rao, 355; Quisumbing, 528; Caius, *J. Bombay nat. Hist. Soc.*, 1938–39, **40,** 305).

The fruit is said to be eaten in times of scarcity in E. Africa. An ink is prepared from ripe fruits in the Philippines. The root is used in Madras as a red dye. Stems are used in N. Nigeria as roof-binders in conical huts; they are also used for making baskets and as chewsticks. The wood is hard, reddish or greyish white; it is used by some tribes in E. Africa for threshing flail. Wood ash in mixture with glue of *Diospyros embryopteris* is used for paving boats (Dalziel, 158; Brown, III, 90; Quisumbing, 528; Rama Rao, 355; Gamble, 509).

**Kittul** — *see* **Caryota**

**KLEINHOVIA** Linn. (*Sterculiaceae*)

A monotypic genus of trees distributed in tropical Asia, Africa and Australia.

**K. hospita** Linn.

D.E.P., IV, 566; Fl. Br. Ind., I, 364; Blatter *et al.*, Pl. XIX.

BENG.—*Bola*; TAM.—*Panaitteku*.

A handsome, medium-sized tree with roundish crown and spreading branches, frequently grown in gardens and as an avenue tree in some parts of India. Leaves simple, alternate, ovate-cordate, 4–6 in. × 3–5 in., entire, acuminate; flowers in large terminal, much-branched showy clusters, small, rose-pink; capsule membranous, inflated, 5-valved; seeds tubercled, 1 or 2 in each cell.

The tree retains its leaves almost throughout the year and looks very attractive in bloom. The flowers appear intermittently from May to November and during cold weather; the delicate tracery of old flower stalks with curious fruits is an added attraction. Being bushy with branches almost reaching the ground, the trees make a fine central object in a shrubbery. It is propagated by seeds, layers or cuttings (Benthall, 55; Gopalaswamiengar, 232; Cameron, 35; Chittenden, III, 1105).

Young leaves and flowers of the tree are eaten as vegetable in the Philippines. A decoction of the leaves is used for skin eruptions and scabies; leaf juice is used as eyewash. The bark and leaves are poisonous and used for killing eels and as hair wash to destroy lice. Leaves contain hydrocyanic acid (Fox, *Philipp. J. Sci.*, 1952, **81,** 237; Quisumbing, 605; Burkill, II, 1281).

The wood is white, soft and light (wt., 28 lb./cu. ft.). The trunk is sometimes knotty and wood extracted from such trees has a twisted appearance and black markings; it is much valued in Java for knife and dagger handles. The bast yields a strong fibre [length, 0.933–2.4 mm.; diam., 0.008–0.031 mm.; mean tensile strength, 309 kg./sq. cm. (dry) and 286 kg./sq. cm. (wet)] used for tying and rope making (Gamble, 99; Burkill, II, 1281; Brown, I, 321, 322, 397).

**KNEMA** Lour. (*Myristicaceae*)

A genus of trees found in south-east Asia and Malaysia. About 4 species occur in India.

**K. angustifolia** (Roxb.) Warb. syn. *Myristica longifolia* Wall. var. *erratica* Hook. f. (Fl. Br. Ind.); *M. gibbosa* Hook. f.

D.E.P., V, 314; Fl. Br. Ind., V, 110 (in part); King, *Ann. R. bot. Gdns, Calcutta*, 1891, **3,** 323, Pl. 162.

ASSAM—*Mota-pasuti, tezranga, mamui*; GARO—*Bol-lanchi*; KHASI—*Dieng-son-lang-snam*; NEPAL—*Ramguwa*.

An evergreen tree, up to 65 ft. high, found in Sikkim Himalayas, Assam, Garo, Khasi and Jaintia hills. Branchlets sometimes tomentose; bark greyish brown with white patches, exfoliating in large thin flakes, reddish inside, exuding copious blood-red juice; leaves variable, usually lanceolate, 4–16 in. × 1.2–3.5 in., thinly coriaceous, pale beneath and shining above; flowers unisexual; fruit 0.75–1.2 in.

long, 2 or 3 borne on axillary, woody tubercles; aril membranous.

The red fluid from the tree is employed in Assam as a varnish; when painted over timber, it renders the wood impervious to moisture. The dried fluid or kino contains 33.6% tannin and resembles Malabar kino (from *Pterocarpus marsupium*) in appearance. It is astringent and is used for dysentery and as an application for mouth sores in Assam (Fl. Assam, IV, 45; Hooper, *Agric. Ledger*, 1900, No. 5, 44; 1902, No. 1, 49).

**K. attenuata** (Wall.) Warb. syn. *Myristica attenuata* Wall.

Fl. Br. Ind., V, 110; King, *Ann. R. bot. Gdns, Calcutta*, 1891, **3**, 316, Pl. 152.

TAM.—*Chora pathiri*; KAN.—*Rukt mara, hedaggal, kaimara*; MAL.—*Chora panu, chen-nelli.*

BOMBAY—*Ragtrorar.*

TRADE—*Jathikai.*

A tall tree with straight cylindrical bole, 20 ft. long × 5–6 ft. girth, found in the evergreen forests of western ghats from Konkan southwards to Travancore, up to a height of 3,000 ft. Leaves 3–9 in. long, elliptic or oblong-lanceolate, acute or acuminate, glaucous above and rusty pubescent beneath; inflorescence furfuraceously tomentose; flowers unisexual; fruits ovoid, 1 1/2 in. long with short point or beak, densely furfuraceously rusty-tomentose; aril brilliant crimson, entire, except towards apex.

The wood is pinkish to pale red when first exposed, ageing to a uniform light reddish brown or pale brownish grey with streaks of dark brown or irregular patches along grains. It deteriorates rapidly in log condition, but seasons with little degrade if converted when green and the planks stacked in the open. It is moderately hard, light (wt., 32 lb./cu. ft.) and fairly durable under cover, but susceptible to insect attack. It saws easily and planes to a shiny smooth surface. The data for its comparative suitability as timber, expressed as percentages of the same properties of teak, are: wt., 75; strength as a beam, 55; stiffness as a beam, 75; suitability as a post, 60; shock-resisting ability, 45; retention of shape, 65; shear, 90; and hardness, 50 [Pearson & Brown, II, 820–22; Limaye, *Indian For. Rec., N.S., Util.*, 1944, **3** (5), 22].

The timber is useful for all purposes where a light, handsome, easily worked wood is required. It should yield a good board-wood and a superior box-wood and may be tested also for three-ply work. It is said

*F.R.I., Dehra Dun. Photo: S. S. Ghosh*

FIG. 165. KNEMA ATTENUATA—TRANSVERSE SECTION OF WOOD (×10)

to be suitable for match boxes and splints, and for light and heavy packing cases. Large quantities of the timber are available from Madras, Mysore, Coorg and Travancore areas, though it is difficult to extract the timber from the dense forests in which the trees are found (Pearson & Brown, II, 820–22; Rama Rao, 340; IS: 399–1952, 33, 35).

A fixed oil is obtained from crushed seeds of the plant by extraction with petroleum ether. On cooling the extract to room temperature, a phytosterol (m.p., 123°) settles out; a second crystalline substance (m.p., 98°), probably a phenolic acid separates on cooling the petroleum ether extract to 0°. The seed fat, free from solvent, has m.p., 34° (Pillai & Nair, *Rep. Dep. Res. Univ. Travancore*, 1939–46, 488).

**K. linifolia** (Roxb.) Warb. syn. *Myristica linifolia* Roxb.; *M. longifolia* Wall. (Fl. Br. Ind.) in part.

Fl. Br. Ind., V, 110; Fl. Assam, IV, 44; King, *Ann. R. bot. Gdns, Calcutta*, 1891, **3**, 324, Pl. 164, 166.

ASSAM—*Garo-bhala*; LUSHAI—*Tring-thi*; KHASI—*Dieng-tyrkhou*; NEPAL—*Ramguwa.*

A lofty tree, up to 60 ft. high, found in North Bengal, N.E.F. tract, Assam, Lushai, Garo, Khasi and Jaintia hills. Bark rough, greyish brown with deep pink blaze, exuding profusely a blood-red juice; leaves 12–20 in. × 2.5 in., elliptic-oblong, coriaceous; flowers unisexual; fruit often solitary, ellipsoid, velvety, 1½–2 in. long, with thin pale yellow aril covering the seed.

The juice exuding from the bark is reported to be caustic; the juice, and the smoke from burning bark, are reported to produce sores. The wood of the tree is cream-coloured; it is used for house building purposes, but is not durable in contact with ground or on exposure to rain (Fl. Assam, IV, 45).

*K. glaucescens* Jack syn. *Myristica glaucescens* Hook. f. (Fl. Br. Ind.) in part, a medium-sized tree with linear-lanceolate leaves and ovoid or obovoid fruits, *c.* 1.0 in. long, is found in the evergreen forests of Assam, Andaman and Nicobar Islands. The correct nomenclature of this species is doubtful. It has been considered by some to be synonymous with *K. malayana* Warb., while according to others they are distinct. In Malaysia, the wood of *K. Malayana* is reported to be used for house building purposes. It is hard (wt., 44–48 lb./cu. ft.), but susceptible to dry-wood termites. The seeds and aril have the odour of black pepper and are eaten by pigeons (Fl. Assam, IV, 45; Parkinson, 223; Burkill, II, 1283; Desch, 1954, II, 380; King, *Ann. R. bot. Gdns, Calcutta*, 1891, **3**, 323).

**Knol-Kohl** — *see* **Brassica**

## KOCHIA Roth (*Chenopodiaceae*)

A genus of villous or pubescent undershrubs or herbs, distributed in middle and south Europe, temperate Asia, N. and S. Africa, Australia and N.W. America. Three species occur in India.

### K. indica Wight

D.E.P., IV, 567; Fl. Br. Ind., V, 11.

Punjab—*Kaura-ro, bui, bui-chhoti.*

An erect, softly hairy annual, with diffuse branches arising from the base and linear, oblong leaves, found in N.W. India from Delhi westwards and also in Deccan Peninsula, in the saline soils of Coimbatore district.

The plant is a common, sometimes troublesome weed, particularly in the irrigated saline soils of Punjab; it also occurs on canal banks, roadsides, etc. It is propagated by seeds and grows vigorously. It is subject to wilt caused by *Rhizoctonia* sp. (Sabnis, *J. Bombay nat. Hist. Soc.*, 1940–41, **42**, 558; Das Gupta & Sharma, *Proc. Indian Sci. Congr.*, 1954, pt III, 127).

FIG. 166. KOCHIA INDICA

*K. indica* thrives well in the desert areas of Egypt, where it was accidentally introduced from India and furnishes fodder for camels; it sometimes develops a prostrate habit, probably as a result of damage to the main shoot by grazing or trampling. Since the plant thrives well in the African desert, it may be tried also in the desert regions of Rajasthan, which lies within the same latitudes [Chatterjee, *Indian Fmg, N.S.*, 1953–54, **3** (2), 20; Thoday, *Kew Bull.*, 1956, 161].

The plant is relished by camels, cattle and mules. Dried plant is used as fuel. The plant is reported to be used as a cardiac stimulant in cases of weak and irregular heart (Chatterjee, loc. cit.; Kirt. & Basu, III, 2080).

*K. prostrata* Schrad. is a villously pubescent, low undershrub with stout, woody rootstock, slender, erect or spreading branches and flat linear leaves. It is found in western Himalayas, in the dry regions of Kunawar and Zanskar, and in western Tibet at altitudes of 10,000–14,000 ft. The plant predominates on light chestnut soils, characteristic of semi-deserts and deserts, in the U.S.S.R. and in association with *Artemisia*, affords good grazing during spring, summer and autumn. Analysis of the plant gave the following values (dry basis): crude protein, 9.8; ether extr., 3.0; crude fibre, 35.3; and N-free extr., 39.2%; *digestible nutrients:* crude protein, 4.1; and starch equivalent, 16.0%. It contains ascorbic acid (Sabnis, loc. cit.: *Jt Publ. imp. agric. Bur.*, 1947, No. 10, 129, 140, 204, 224; *Chem. Abstr.*, 1954, **48,** 12242).

*K. scoparia* Schrad. is a tall herb, 3–5 ft. high with erect branches found in N.W. India. It is reported to be eaten by cattle. Trials carried out in Canada show that an annual yield of 3.1–5.0 tons of dry matter per acre can be obtained. Analysis of early cut plants gave: dry matter, 86.9; crude protein, 18.7; ether extr., 2.1; crude fibre, 17.1; N-free extr., 32.3; and total ash, 16.7%; carotene, 19 mg./lb.; *digestible nutrients* (dry basis): crude protein, 18; and total nutrients, 57%. The plant is resistant to drought and grasshoppers, is rich in protein and carbohydrates, and yields hay and silage of high potentiality. In old plants (about 3 ft. in height) the main stem becomes rather hard and woody, when it becomes less suitable as a dry forage crop (Bell *et al.*, *Sci. Agric.*, 1952, **32,** 463).

The plant is reported to be used, sometimes, for making brooms. It is used in China for medicinal purposes: the fruits and leaves are said to possess cardiotonic and diuretic properties. The leaves and seeds contain saponin (Neal, 284; Roi, 120; Kirt. & Basu, III, 2081; Wehmer, I, 287).

A form and variety of *K. scoparia*, commonly known under the name *K. trichophylla* Voss. (Summer Cypress, Fire Bush) is cultivated in gardens for its dense, globular or pyramidal habit, and narrow, needle-like leaves, which turn purple when old (Bailey, 1947, II, 1755; Gopalaswamiengar, 441).

## KOELERIA Pers. (*Gramineae*)

A small genus of annual or perennial grasses distributed throughout the temperate regions of the world. About 4 species are recorded in India.

**K. cristata** Pers. Crested Hair Grass

D.E.P., IV, 567; III, 436; Fl. Br. Ind., VII, 308.

A slender, densely tufted, stoloniferous perennial, 1–3 ft. high, with narrow flat leaves, found from Kashmir to Nepal at altitudes of 5,000–13,000 ft. It is sometimes grown for lawn decoration on open dry ground. The grass yields a good fodder. Analysis of grass from Gulmarg (9,000 ft.) gave the following values (dry basis): protein, 8.85; ash, 8.29; ether extr., 2.59; crude fibre, 38.52; carbohydrates, 40.65; calcium (CaO), 0.50; and phosphorus ($P_2O_5$), 0.60%. The ash is reported to be rich in silica (Bailey, 1947, II, 1755; Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26,** 442; Wehmer I, 78).

*K. phleoides* Pers. is an erect or ascending annual, 1–2 ft. high, with erect, flat, acuminate leaves, recorded in Kashmir, Punjab and Delhi. It is considered to be a good fodder grass. Analyses of grass from Srinagar and Thratay (5,000 ft.) gave the following values respectively (dry basis): protein, 10.96, 5.91; ash, 18.93, 14.90; ether extr., 2.14, 2.91; crude fibre, 24.73, 33.03; carbohydrates, 41.68, 41.85; calcium (CaO), 0.87, 0.65; and phosphorus ($P_2O_5$), 0.69, 0.74% (Stewart, *Brittonia, N.Y.*, 1945, **5,** 430; Chopra *et al.*, loc. cit.).

**Kohlrabi** — *see* **Brassica**

**Kokam Butter Tree** — *see* **Garcinia**

**Kokko** — *see* **Albizzia**

**Kola Nut** — *see* **Cola**

**Kuth** — *see* **Saussurea**

## KOPSIA Blume (*Apocynaceae*)

Fl. Br. Ind., III, 639; Corner, I, 145; II, Pl. 21.

A small genus of trees or shrubs, natives of tropical Asia, distributed eastwards to the Philippines. A few species are cultivated in Indian gardens for ornament.

*K. fruticosa* A. DC. (Pink Kopsia; Tel.—*Gutti-ganneru*) is a handsome evergreen shrub, 4–6 ft. high, with glossy lanceolate leaves and pretty pink flowers, which appear nearly throughout the year. It is a native of Burma, often cultivated in Indian gardens for ornament. It thrives in partially shaded situations in any good soil and can be propagated by seeds, cuttings or layering (Gopalaswamiengar, 277; Benthall, 302).

The leaves and bark of the plant contain a bitter indole alkaloid, kopsine [$C_{22}H_{26}O_4N_2$; m.p., 217–18° (decomp.); $[\alpha]_D^{20°}$, +16.4° (in alcohol)], which on

mild hydrolysis with alcoholic ammonia gives kopsidine [$C_{20}H_{24}O_3N_2$ ; m.p., 142° (decomp.)] ; kopsidinine [$C_{19}H_{22}O_2N_2$ ; m.p., 248° (decomp.)] is obtained from kopsine by hydrolysis with strong alkali. Mature leaves of the plant contain 0.12% kopsine and the bark, 0.06%. Kopsine forms well defined salts with perchloric, picric, oxalic and other organic acids, but not with mineral acids, because of resinification. It has been found to possess cholinergic action. The seeds are reported to contain 1.7% of an alkaloid (Wehmer, II, 989 ; Bhattacharya *et al.*, *J. Amer. chem. Soc.*, 1949, **71,** 3370 ; Bhattacharya, ibid., 1953, **75,** 381 ; *Sci. & Cult.*, 1956–57, **22,** 120 ; Mukherjee *et al.*, *Nature, Lond.*, 1957, **180,** 916).

The plant is reported to have been used as a source of arrow poison. In Malaya, the root of this and other species of *Kopsia* is used for poulticing ulcerated noses in tertiary syphilis (Bhattacharya *et al.*, loc. cit. ; Burkill, II, 1286).

*K. albiflora* Boerl. syn. *Calpicarpum albiflorum* Teijsm. & Binn. is a native of Malaysia, reported to be cultivated in Indian gardens. The seeds and leaves contain an alkaloid ; the latter contain 0.01% of kopsine (Wehmer, II, 989 ; Bhattacharya, *Sci. & Cult.*, 1952 53, **18,** 293 ; 1956–57, **22,** 120).

*K. flavida* Blume, a medium-sized tree, native of rain forests at low altitudes in Java, is highly ornamental when in bloom. The seeds of this plant, as also those of *K. arborea* Blume, also a native of Java, contain an alkaloid (Neal, 609 ; Wehmer, II, 989 ; Chopra, 501 ; Burkill, II, 1286).

**Kousso** — *see* **Hagenia**

**Kraits** — *see* **Snakes**

**KRAMERIA** Loefl. (*Leguminosae* ; *Polygalaceae*)

D.E.P., IV, 568 ; Bailey, 1947, II, 1757.

A small genus of woody shrubs or perennial herbs, native of the warmer parts of America. The roots of some of the species are medicinal.

*K. triandra* Ruiz & Pav. is a low spreading shrub, distributed in Peru and Bolivia. The dried roots of the plants were formerly official in B.P. and U.S.P. under the names Peruvian Rhatany and Krameria Roots (Radix Ratanhiae), and are reported to be imported into India. Peruvian rhatany has a knotty or many-headed crown and numerous branching rootlets ; the bark is thick, about one-third the radius of the root, and can be easily peeled. The drug is odourless ; the bark has a strongly astringent taste, but the wood is practically tasteless.

The activity of the drug is attributed to the presence of a phlobatannin, krameria (rhatania) tannic acid (8–9%), which is concentrated mostly in the bark. Other constituents present in the drug are: krameria red (formed by the decomposition of tannin), rhatanine (N-methyl tyrosine, 0.7%), krameric acid, starch, saccharine matter, a wax, a gum and calcium oxalate. The roots contain c. 40% total tannin ; they are used along with other tannins for tanning leather to a deep brown colour (B.P., 1948, 302 ; U.S.D., 1955, 1731 ; Youngken, 442–44 ; Trease, 424–25 ; Wehmer, I, 507 ; Brady, 592 93 ; Howes, 1953, 280).

Peruvian rhatany has been used as an astringent and tonic in the form of dry extract and in tinctures. It has been used successfully in chronic diarrhoea and passive haemorrhages, and locally in leucorrhoea and ophthalmia. The powder mixed with chalk or myrrh is useful as a dentifrice, particularly for spongy and bleeding gums. It is used also for mucous discharges in menstrual disorders and incontinence of urine. Lozenges containing rhatany and cocaine are reported to be useful for coughs and sore throat. Tinctura Krameria (after dilution with water) is used in gargles for inflamed throat and as mouth wash in stomatitis. Extractum Krameriae Siccum is given in pills as an intestinal astringent ; it is also used, with opium, as a suppository for bleeding or prolapsed haemorrhoids. In the form of an ointment, it promotes epithelization of wounds. Preparations of krameria are incompatible with gelatin and with salts of iron (Wren, 295 ; Allport, 209 10 ; Steinmetz, II, 377 ; U.S.D., 1955, 1731 ; B.P.C., 1949, 466).

*Krameria argentea* Mart., a Brazilian species, yields Para Rhatany which is used as a substitute for Peruvian Rhatany. Other species of *Krameria* yielding rhatany roots are *K. tomentosa* St. Hil. syn. *K. ixina* Linn. (Savanilla Rhatany) and *K. parvifolia* Benth. (Range Rhatany) (Wallis, 357 ; Trease, 424 ; Youngken, 442 ; B.P.C., 1949, 465 ; U.S.D., 1955, 1731 ; Wehmer, I, 508 ; Krochmal *et al.*, *Econ. Bot.*, 1954, **8,** 3).

The roots of Indian Sarsaparilla (from *Hemidesmus indicus* R. Br.) are sometimes used as substitute for rhatany. Large pieces of Indian sarsaparilla occasionally bear a resemblance to small pieces of para rhatany ; they are readily distinguished from the latter by their agreeable odour, resembling coumarin, and by the difference in the transverse section (Wallis, 358).

**Kudzu** — *see* **Pueraria**

**Kulang** — *see* **Birds**

**Kumbi** — *see* **Careya**

**Kumquat** — *see* **Fortunella**

**Kurchi** — *see* **Holarrhena**

**KURRIMIA** Wall. (*Celastraceae*)

A small genus of trees distributed in south-east Asia and Malaysia. Two species occur in India.

**K. indica** (Bedd.) Gamble syn. *K. bipartita* M. Laws. : *K. paniculata* M. Laws. (Fl. Br. Ind.) in part, non Wall.

Fl. Br. Ind., I, 622 : Fl. Madras, 207.

TAM. -*Kadapla*.

A large evergreen tree with large, coriaceous, conspicuously nerved leaves, found in the evergreen forests of western ghats, Anamalais, hills of Tinnevelly and Travancore at altitudes of 3,000-6,000 ft. Flowers pale yellow : capsule with two oblong, equal lobes, 1.5 in. long.

The wood of *K. indica* (wt., 34–43 lb./cu. ft.) is pale greyish brown and moderately hard. The timber from the allied species, *K. paniculata* Wall. ex M. Laws., occurring in Malaysia, is reported to be used for posts, beams and floor boards. The fruit is eaten, but the pulp is reported to be tasteless (Gamble, 177–78 ; Burkill, II, 1288 ; Corner, I, 190).

**K. robusta** (Roxb.) Kurz syn. *K. pulcherrima* Wall. ex M. Laws.

Fl. Br. Ind., I, 622 ; Fl. Assam, I, 270.

ASSAM -*Hinguri* ; KHASI -*Dieng-mat-wei* ; *dieng-soh-gang*.

A large tree, up to 90 ft. in height and 5 ft. in girth, with oval crown and spreading branches, found in north Bengal, Assam, Khasi hills and south Andaman Islands. Leaves oblong-lanceolate, 4–7 in. × 1–2 in. : fruits 1½–2 in. long, one-celled and one-seeded. The wood (wt., 44–48 lb./cu. ft.) is reddish brown and coarse-grained, with close concentric lines of soft tissue. It is said to be brittle and not durable ; it is considered excellent for cabinet work in Malaya (Burkill, II, 1288).

**Kusam** — *see* **Schleichera**

**Kuthan** — *see* **Hymenodictyon**

## KYANITE

Kyanite is an aluminium silicate mineral ($Al_2O_3$. $SiO_2$ ; $Al_2O_3$, 62.93 and $SiO_2$, 37.07% ; sp. gr., 3.6 : H., 4–7) crystallizing in the triclinic system. It occurs usually as long-bladed crystals or as fine grained massive rocks.

The mineral has the same chemical composition as andalusite and sillimanite, but differs from them in physical and crystallographic properties. It is denser than andalusite (sp. gr., 3.15) and sillimanite (sp. gr., 3.23). Its hardness varies along different faces ; thus in the bladed triclinic form, the hardness along the length is 4–5, that across is 7 ; due to this property, kyanite is sometimes known as Disthene. When heated to 1540°, kyanite is converted, with expansion in volume, into mullite ($3Al_2O_3.2SiO_2$), a stable refractory ; on raising the temperature beyond 1810°, mullite begins to soften.

Kyanite is of metamorphic origin derived from aluminous sediments, and occurs chiefly in gneisses and schists, often associated with corundum, andalusite, staurolite, garnet, and rutile. Pure kyanite is colourless, but due to the presence of impurities the mineral is usually pale sky blue to deep blue in colour ; greenish and yellowish varieties are also found. Transparent varieties are used as gem stones. Kyanite is used in industry, after calcining, as a refractory, especially for lining glass furnaces and furnaces for smelting non-ferrous metals.

Kyanite occurs widely, usually, disseminated in small quantities, with other minerals. In commercial quantities and grades, it is found only in a few countries notably in India, U.S.A. and Kenya ; it is also found in Australia and U.S.S.R. The largest deposits in the world are found in Bihar. In 1954, India was the leading producer of kyanite with an output of 42,330 tons, followed by U.S.A. (36,000 tons) and Kenya (4,018 tons). However, in 1955 and 1956 the production of kyanite in India was much lower than in U.S.A.

### DISTRIBUTION

*Andhra Pradesh* -In Nellore district, kyanite occurs associated with quartzite and quartz schists near Chundi Chattram (15°6′ : 79°38′) in a series of ridges striking N.N.E. to S.S.W., terminating at Malekonda hill. The mineral ($Al_2O_3$, c. 58%) occurs in the form of lenses, sometimes up to 20 ft. long. The deposits are irregular and the reserves, within a depth of 10 ft., are estimated at 2,000 tons [*Rec. geol. Surv. India*, 1955, **79** (pt 2), 668].

A small deposit of kyanite is found in the mica schists of the hillock, north-west of Saidapuram (14°10′ : 79°44′) in the Nellore mica belt. The mineral is found in pockets and lenses over a length of 200

yd. Transparent gem varieties of kyanite occur in this locality and also at Chundi Chattram (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 154).

In Warangal taluk, kyanite occurs in small quantities in granite quarries near Gharibpet (17°29′:80°38′) (Chatterji, *Indian Ceram.*, 1954–55, **1,** 176).

*Bihar*—Kyanite occurs in a belt, about 80 miles long × 10 miles wide, stretching east along the western part of the former Seraikela State through part of northern Singhbhum, thence through Kharswan and Seraikela into Dalbhum, turning to the south-east as far as Shivai Dungri (22°21′ : 86°40′). For a greater part of the length, it follows the northern flank of the Singhbhum copper belt.

The most important deposit is found at Lapsa Buru (22°48′:85°44′) in the former Kharswan State, where massive kyanite occurs in association with corundum as segregations in the more acidic kyanite-quartz rocks. Some deposits are composed of almost pure kyanite. Specimens of kyanite from the deposit analyzed to $Al_2O_3$, 61.4–65.0 ; $SiO_2$, 32.5–35.4 ; $Fe_2O_3$, trace–1.5 ; CaO, 0.6–3.1 ; and $TiO_2$, 0.52%. The reserves at Lapsa Buru deposit are estimated at 700,000 tons up to a depth of 10 ft. (Dunn, *Mem. geol. Surv. India*, 1941, **78,** 154 : *Mineral Production in India*, Indian Bureau of Mines, 1956, 78).

The principal deposits of massive kyanite in Singhbhum district are found near Ghagidih (22°45′: 86°11′) ; between Badia (22°30′:86°28′) and Bakra (22°29′:86°11′) ; near Kanyaluka (22°28′:86°31′) : and at Mohanpur (22°34′:86°32′). The kyanite from Ghagidih analyzed to $Al_2O_3$, 60.7–60.8 ; $SiO_2$, 34.7–36.0 ; $Fe_2O_3$, 0.07–2.3; and $TiO_2$, 1.18–1.2%. Transparent gem varieties of kyanite occur near Badia. The Kanyaluka mineral is rather high in iron and is not suitable for use as a refractory. Some of the workable deposits in the district are getting rapidly exhausted.

Deposits of lesser importance are found at Rakha Mines (22°38′:86°22′) ; Uparbanda (22°34′:86°28′) ; Chirugora (22°33′:86°31′) ; Bhakar (22°23′:86°36′) ; Shirbai (22°21′ : 86°39′) ; Singpura (22°22′ : 86°35′) ; and Daontanri (22°30′:86°9′). Massive kyanite rock of commercial grade has been found only at Uparbanda ; samples from the deposit analyzed to $Al_2O_3$, 59–64 ; $SiO_2$, 31–36 ; $Fe_2O_3$, 0.7–1.0 ; and $TiO_2$, 0.21–3.00%. Specimens containing segregations of both kyanite and andalusite have been observed south and west of Daontanri.

In Manbhum district, small deposits of kyanite rock occur along a narrow belt extending from Ichadih (22°4′: 86°10′) to Salbani (23°4′:86°17′). Due to its high mica content, the rock is of little commercial importance. The reserves in this area have been estimated at 6,000 tons. Massive coarse-bladed kyanite of poor quality also occurs at Rangadih (23°1′: 85°53′). Occasional blocks and pieces of kyanite are found scattered on the surface of mica schists between Barabhum railway station and Berasi Siram (23°7′:86°1′) ; the kyanite is usually associated with corundum. Though the deposits are sparsely distributed over a wide area, those near Berasi Siram, Haitiral (23°6′:86°3′) and Bandudih (23°6′:86°6′) appear to be worth prospecting. A specimen from Bandudih analyzed to $Al_2O_3$, 63.75 ; $SiO_2$, 30.90 ; $Fe_2O_3$, 3.25 ; and CaO, 2.18% [*Rec. geol. Surv. India*, 1953, **84** (pt 1), 78 ; Dey, *Rec. geol. Surv. India*, 1954, **80,** 410].

In the former Seraikela State, deposits of kyanite occur as segregations in quartz-kyanite rocks and also as detrital boulders between Padampur (22°48′: 85°55′) and Kuku Dungri (22°47′:86°1′). Boulders of kyanite rock are fairly abundant on the slopes of Bidag hill and in the plains surrounding it, about 1½ miles west of Nakti (22°43′:85°30′). Smaller deposits are found at Karaikela and Jhar Gobindpur (22°48′:86°5′) [Gupta, *Rec. geol. Surv. India*, 1955, **79** (pt 2), 543].

*Bombay*—In Bhandara district, small quantities of kyanite-topaz-dumortierite occur at Mogra, Girola, Ganglewara, Sonekhari, Pawar Dawna and Sarethi. The deposits are of poor quality.

*Madras*—In Coimbatore district, small quantities of kyanite occur near Kanjikovil (11°22′:77°36′) in association with corundum. Transparent varieties of the mineral are used as gem stones (Krishnan, *Mem. geol. Surv. India*, 1951, **80,** 154).

*Mysore*—In Hassan district, kyanite occurs in Thirumalapur and Mavinkere taluks. The mineral occurring in the Thirumalapur area is of bladed variety, and the reserves are estimated to be not more than 50,000 tons ; however, there are other areas in the same region containing kyanite. In Mavinkere taluk, massive bluish kyanite occurs, in association with corundum, in an area 880 yd. long × 220 yd. wide. Investigations of the exposed area indicate that the load extends beyond a depth of 30 ft. The mineral contains 58–62% alumina and the reserves in this area are estimated at 250,000 tons up to a depth of 30 ft. (Narayanaswamy, *Indian Minerals*, 1954, **8,** 158 : *Miner. Yearb., Wash.*, 1950, 1348).

*Orissa*—In Mayurbhanj district, kyanite-quartz rock occurs about 3 furlongs east of Panijia (22°3′: 86°41′). The rock is often free from quartz, mica and tourmaline, and is suitable for industrial use. The eastern flank of the deposit is rich in dumortierite. Kyanite specimens from this deposit contain 50–58% alumina and the reserves in this area are estimated at 1,500 tons. Small quantities of kyanite are being extracted from this deposit [Iyengar, *Rec. geol. Surv. India*, 1954, **86** (pt 1), 103].

*Punjab*—Kyanite of the gem variety occurs near Narnaul, Kanaur and Bashahr in Patiala division.

*Rajasthan*—Small veins and pockets of coarse bladed kyanite have been found near Kishangarh (26°35′: 74°52′), Sansera (25°5′: 73°45′), Dewal (23°57′: 73°36′), Warlia (23°42′: 74°3′), Saroda (23°45′: 74°7′) and Gudos (26°29′: 74°46′). The occurrences are of minor importance [Sethi, 112; Sinha, *Rec. geol. Surv. India*, 1949, **82** (pt 1), 56].

### Mining, Treatment and Uses

Kyanite is quarried or merely picked up from surface soil. Larger blocks are broken before dispatch. The presence of corundum in the rock is advantageous, as it reduces the percentage of free silica formed when kyanite is calcined to mullite.

The suitability of kyanite rocks for commercial use is determined by its chemical composition. For refractory purposes, kyanite should contain but negligible quantities of impurities like iron oxide, free silica, oxides of calcium and manganese, and alkali; these impurities markedly reduce the softening point of mullite and so affect the utility of

**TABLE 1—PRODUCTION OF KYANITE IN INDIA**

(Qty in tons and val. in thousand Rs.)

| | Qty | Val. |
|---|---|---|
| 1932–36 (av.) | 12,792 | 196.2 |
| 1937–41 (av.) | 22,682 | 541.2 |
| 1942–46 (av.) | 16,300 | 407.3 |
| 1947–51 (av.) | 24,538 | 2,367.1 |
| 1952 | 26,882 | 6,316.9 |
| 1953 | 15,374 | 2,366.0 |
| 1954 | 42,330 | 8,781.0 |
| 1955 | 11,741 | 1,671.0 |
| 1956 | 20,135 | 4,714.0 |
| 1957† | 18,120 | 4,390.0 |

†Provisional.

**TABLE 2—STATE-WISE PRODUCTION OF KYANITE**

(Qty in tons)

| | 1954 | 1955 | 1956 | 1957† |
|---|---|---|---|---|
| Andhra Pradesh | 32 | 20 | 289 | 13 |
| Bihar | 41,874 | 11,486 | 19,846 | 18,107 |
| Mysore | 286 | 11 | .. | .. |
| Orissa | 138 | 224 | .. | .. |
| Total qty (tons) | 42,330 | 11,741 | 20,135 | 18,120 |
| Total val. (thousand rupees) | 8,781 | 1,671 | 4,714 | 4,390 |

†Provisional.

**TABLE 3—PRODUCTION OF KYANITE (GRADEWISE) IN 1956 AND 1957**

(Qty in tons)

| | | Per cent alumina ($Al_2O_3$) | | | | |
|---|---|---|---|---|---|---|
| | | 45–50 | 50–55 | 55–60 | Above 60 | Total |
| 1956 | Bihar | 30 | 1,114 | 17,826 | 876 | 19,846 |
| | Andhra | | | 289 | | 289 |
| 1957 | Bihar | | | 16,465 | 882 | 18,107 |
| | Andhra | | | 13 | | 13 |

**TABLE 4—EXPORTS OF KYANITE**

(Qty in tons and val. in thousand Rs.)

| | Qty | Val. |
|---|---|---|
| 1951–52 | 22,592 | 4,925 |
| 1952–53 | 21,621 | 6,809 |
| 1953–54 | 15,168 | 3,796 |
| 1954–55 | 24,314 | 5,944 |
| 1955–56 | 31,323 | 7,730 |
| 1956–57 | 24,924 | 7,421 |
| 1957 | 24,456 | 7,525 |
| 1958 | 19,158 | 5,671 |

**TABLE 5—PRICE OF KYANITE (F.O.B.) CALCUTTA*—1954-57**

(Rs. per ton)

| Grade | 1954 | 1955 | 1956 | 1957 |
|---|---|---|---|---|
| High grade ($Al_2O_3$, 68%) | 260 | 280 | 300–350 | 330–350 |
| Low grade ($Al_2O_3$, 58%) | 130 | 160–170 | 160–190 | 190–210 |

*Information from the Bengal Chamber of Commerce, Calcutta.

kyanite as a refractory. For eliminating the impurities, the quarried rock is crushed and concentrated by froth flotation; quartz and other heavier impurities settle down and are removed; limonite, magnetite and pyrite are removed by magnetic separation. The mineral may or may not be calcined before shipment. Indian kyanite, dressed and calcined in U.K., is marketed there under the trade name P.B. Sillimanite. It contains small proportions of corundum, lime, and oxides of iron and titanium, which together amount to less than 3%. Indian kyanite is much prized as it exhibits low thermal expansion and produces hard grog with high constancy in volume.

*Uses*—Kyanite is valued as a refractory lining material in furnaces used for melting glass and non-ferrous metals, e.g. brass, bronze and aluminium. It is also used for lining cement clinkering kilns. Bricks and blocks of calcined kyanite or sillimanite, formed by bonding with high aluminous clay (10–25 parts of clay and 75–90 parts of calcined kyanite), are employed in high temperature equipment for supporting heavy loads and for constructing parts which are required to resist the action of acidic or alkaline slags. Calcined kyanite is ground and shaped with binding materials into pots and tanks, retorts, crucibles, saggars, muffles, etc. Kyanite is used as a glass batch constituent to increase the alumina content of glass. Finely ground mullite is added to kaolin or clay mixtures for reducing firing shrinkage, increasing breaking strength, improving abrasion resistance, and for lengthening the sintering range of ceramic wares. Due to its high electrical resistance, calcined kyanite is employed as a constituent of electrical procelain. Transparent varieties of kyanite are used as gem stones after cutting.

*Quality and grade*—For use in refractories, a hard tough grog of low porosity is desired. Massive kyanite is preferred to coarse-bladed varieties which yield a fragile, highly porous grog. For use in glass and electrical porcelain, the iron content of kyanite should not exceed 0.2%.

The mineral is marketed in two grades—high grade kyanite ($Al_2O_3$, 68%) and low grade kyanite ($Al_2O_3$, 58%).

### Production and Trade

Tables 1 and 2 give the production of kyanite in India; Table 3 gives the grade-wise production in 1956 and 1957.

*Exports*—The major part of the kyanite produced in India is exported; only a small quantity is consumed within the country. Table 4 gives the exports of kyanite from India. The principal importers of Indian kyanite are U.K. and U.S.A.

*Prices*—Table 5 gives the prices of high and low grade kyanite, f.o.b. Calcutta, during 1954–57.

## KYDIA Roxb. (*Malvaceae*)

A small genus of trees found in India, Burma, Malaya and northern Siam. Three species occur in India.

### K. calycina Roxb.

D.E.P., IV, 568; Fl. Br. Ind., I, 348; Blatter *et al.*, Pl. 20.

Hindi—*Pula, choupultea, pathra, polao*; Beng.—*Pola, bonkopas*; Guj.—*Mhotihirwani, nihotilirwani*; Mar.—*Warung, bhoti, potari*; Tam.—*Vendai*; Tel.—*Potri, kondapotari, pachabotuka, pandiki*; Kan.—*Bellaka, nayibende*; Mal.—*Velukku, nedunar, venta*; Oriya—*Bankopasia, bharimo*

Assam—*Pichhola, bankopah*; Khasi—*Dieng-misiri*; Lepcha—*Dansasiyok*; Nepal—*Kubinde*; Punjab—*Pola, pula.*

Trade (timber)—*Pula.*

A small or moderate-sized deciduous tree, up to 40 ft. in height and 3–4 ft. in girth, with a clean bole of 15–20 ft., found throughout the greater part of India, chiefly in mixed deciduous forests but not in arid areas; it is common in the sub-Himalayan tract. Bark grey, exfoliating in irregular flakes or thin long strips; leaves alternate, 4–5 in. × 3–4 in., lobed, angled or rounded, cordate, palmately nerved, closely felted beneath; flowers polygamous, greenish white or purplish in much-branched panicles; capsules small, globose, 3-valved, tomentose; seeds reniform, dark brown. The tree is grown for ornament and is particularly attractive in flower during September–November.

*K. calycina* is a light-demander, but can tolerate moderate shade in infancy. It is fairly frost-hardy and drought-resistant. It is comparatively short-lived, but its rapid growth after the first season enables it to push its way through gaps in forests, till it reaches a height of 30 ft. or more, when it is overtaken and suppressed by large and long-lived trees. It is a useful nurse for *sal* but should be cut when it tends to get invasive. In teak plantations, the light-demanding teak suffers seriously if *K. calycina* is not removed in time. It coppices well, pollards satisfactorily and also produces root suckers.

Natural reproduction takes place freely by seeds

*F.R.I., Dehra Dun. Photo: H. G. Champion*

FIG. 167. KYDIA CALYCINA—TREES LOPPED FOR FODDER

which have low germinating power, but are produced in great abundance. The seeds are often washed up in early rains into heaps mixed with dead leaves and loose soil, and such conditions are favourable for germination.

Artificial reproduction is usually done by transplanting nursery-raised seedlings (2–3 in. high) either entire or after pruning the roots and shoots; pruning has been reported to be advantageous in some cases. Stumps, 0.4–0.9 inch in diam., are also suitable for planting. Direct sowing in U.P., tree stumping in Mysore, and propagation by root pieces under garden conditions in Dehra Dun, have proved successful (Troup, I, 147–49; Kadambi, *Indian Pulp Pap.*, 1954 55, **9,** 57; Kadambi & Dabral, *Indian For.*, 1955, **81,** 129).

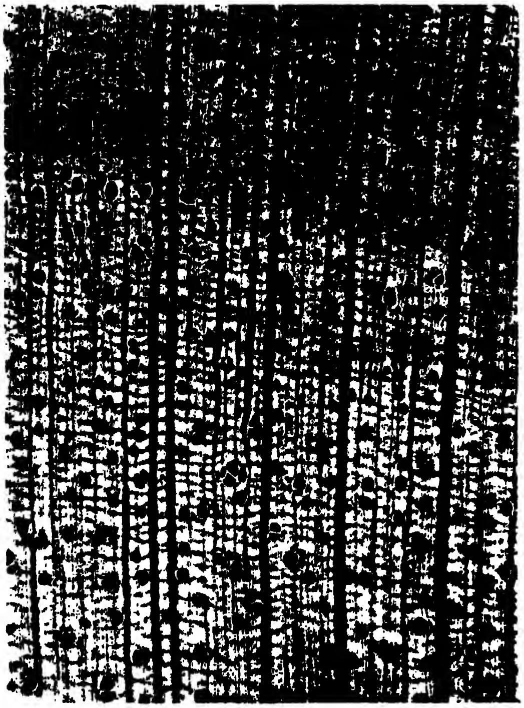
The rate of growth is rapid. Natural untended plants are reported to have attained a height of 25–30 ft. in 5 years in U.P.. observations carried out in a sample plot in U.P. showed that trees attained a height of 40 ft. in 15 years (Troup, I, 149; Kadambi, loc. cit.).

The sapwood is white and heartwood brownish or purplish grey, dull, straight-grained, even- and coarse-textured, moderately hard, strong and light (sp. gr., c. 0.3; wt., 31–37 lb./cu. ft.). It is very liable to warp and stain. It is not refractory to seasoning; green conversion and prompt stacking in open piles are recommended; kiln-seasoning may also give satisfactory results. The wood is not durable in exposed situations, but is fairly so under cover. It is liable to insect attack, but treatment with a salt solution or powellizing may render it proof against insects. The wood is easy to saw and works to a good surface (Pearson & Brown, I, 133–35; Kadambi, loc. cit.).

Seasoned wood yields planks useful for interior work in building construction. It is used to a limited extent for agricultural implements, oars, carving, spoons and ladles, match boxes and splints and light packing cases. It is also reported to be suitable for picture and slate frames, but raising of grain has been observed during grooving and chamfering; it is also liable to crack while nailing. The wood is suitable for veneers and plywood, brush backs, turnery, toys and other small articles, bobbins and shuttles, carriage and wagon work, shoe heels and core work; it may also be used for cheap grades of pencils. In Gujarat, the timber is used for well construction, canal work, water wheels, etc. Sapling stems are strong and elastic and suitable for *banghy* sticks (Pearson & Brown, I, 134–35; Krishnamurti Naidu, 79; Rehman *et al.*, *Indian For.*, 1954, **80,** 626; *Indian For.*, 1952, **78,** 277; *IS*: 399–1952, 8, 10; Kapadia, *J. Gujarat Res. Soc.*, 1954, **16,** 3; Trotter, 1944, 199, 220).

The wood yields a mechanical pulp (yield, 82.6% on dressed pieces) of light shade, but poor strength due to the short length of the ultimate fibres. The pulp can be used, in admixture with 30% bamboo chemical pulp, for newsprint, although the paper obtained compares unfavourably in strength properties with imported newsprint. Strength tests on newsprint from Kydia-bamboo pulp gave the following values: burst factor (Ashcroft), 5.20; tear factor, 43.0; breaking length, 896.9 m., and elongation, 1.2% (Bhargava & Kartar Singh, *Indian For. Bull.*, *N.S.*, No. 108, 1941, 1).

The inner bark yields a fibre (cellulose, 70.2%) used locally for coarse ropes. The fibre is strong when green, but becomes brittle on drying. Ropes made



F.R.I., Dehra Dun. Photo: K. A. Chowdhury

FIG. 168. KYDIA CALYCINA—TRANSVERSE SECTION OF WOOD (×10)

from the bark fibre are used for tying rafts; they are sometimes used as elephant drag ropes. The young bark is mucilaginous and a cold infusion of it is used in gur making for clarifying sugarcane juice. It also contains a gum. The wood is used as fuel (calorific val.: 5,067 cal., 9,122 B.t.u.), though it burns with an unpleasant smell: it is also used for making charcoal. The wood is a good source of commercial potash (yield, 0.41%). Analysis of wood ash (1.67%) gave the following values: total solubles, 36.57: $K_2CO_3$, 33.25: KCl, 1.96: $K_2SO_4$, 1.33: and insoluble matter, 59.81% (*Econ. Bot.*, 1953, **7**, 189: Dastur, Useful Plants, 134: Krishnamurti Naidu, 80: Dymock, Warden & Hooper, I, 228: *Indian For.*, 1948, **74**, 279; Krishna & Ramaswami, *Indian For. Bull., N.S.*, No. 79, 1932, 19; Mata Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 14–15).

The tree is valued for the leaves which are lopped for fodder. A five-year old plantation yielded 6,900 lb. of green fodder per acre. Analysis of mature leaves lopped in March at Clutterbuckganj (U.P.) gave the following values (dry basis): crude protein, 13.6: lime (CaO), 7.3: phosphate ($P_2O_5$), 1.1%. The plant is one of the recorded hosts of the Indian lac insect (Laurie, *Indian For. Leafl.*, No. 82, 1945, 9: Kadambi, loc. cit.: Chaturvedi, *Bull. U.P. For. Dep.*, No. 19, 1948: Burkill, II, 1288).

A paste of the leaves is applied in body pains: leaves are used also in poultices for skin diseases. Leaves are chewed when there is a deficiency of saliva (Kirt. & Basu, I, 350: Cameron, 28).

**KYLLINGA** Rottb. (*Cyperaceae*)

A small genus of annual or perennial herbs, distributed in the tropical and sub-tropical regions of the world. About 8 species occur in India.

**K. brevifolia** Rottb.=*Cyperus brevifolius* (Rottb.) Hassk.

Fl. Br. Ind., VI, 588.

An erect, glabrous, perennial herb, up to 2 ft. high, with slender creeping rhizome up to 8 in. long, found throughout India, usually in soft sticky soil along the banks of streams and other wet places. Stems usually distant, sometimes contiguous: leaves linear, as long as or much shorter than the stems.

*K. brevifolia* is readily eaten by cattle. Analysis of the plant gave the following values (dry basis): protein, 8.47: fat, 0.94: starchy substances, 45.0: raw fibre, 29.86: and ash, 15.73%. The plant is reported, in Australia, to cause scouring, especially in young stock (Burkill, II, 1289: Walandouw, *J. sci. Res. Indonesia*, 1952, **1**, 201: Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 48: Connor, *Bull. Dep. sci. industr. Res., N.Z.*, No. 99, 1951, 114).

The roots and rhizomes are strongly aromatic with a gingery odour. In Malaya, the rhizomes are applied in poultices for sores on the legs: leaves are taken internally for diarrhoea (Blatter, *J. Bombay nat. Hist. Soc.*, 1934 35, **37**, 22: Burkill, II, 1289).

**K. monocephala** Rottb.=*Cyperus kyllingia* Endl.

D.E.P., IV, 569: III, 415: Fl. Br. Ind., VI, 588: Kirt. & Basu, Pl. 1009 B.

Hindi & Beng.—*Nirbishi, shwetgothubi*; Mar.—*Mustu*; Mal.—*Mottenga, pimottenga.*

Delhi—*Bhada, motha.*

An erect creeping sedge, up to 1 ft. high, with well-developed rhizomes, common throughout India, particularly in shady and moist places. Leaves linear, as long as or shorter than, the stem: spike white, globose, solitary, terminal.

*K. monocephala* is eaten by cattle. Analysis of the plant gave the following values (dry basis): protein, 10.59: fat, 0.86: starchy substances, 42.36: raw fibre, 27.25: and ash, 18.94%. The plant, according to a

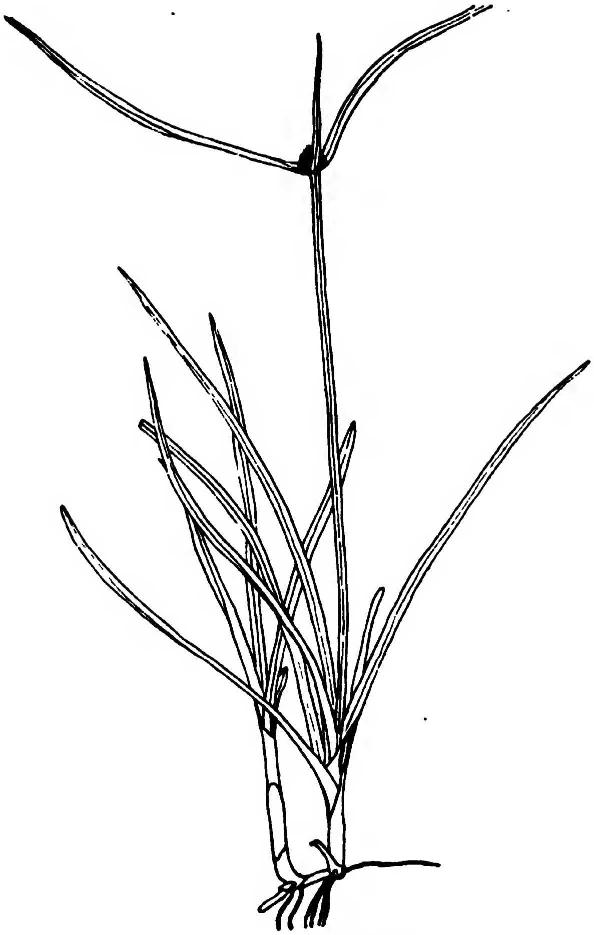


FIG. 169. KYLLINGA MONOCEPHALA

report from Australia, is injurious to cattle, particularly when given in the seeding stage, causing purging, diarrhoea and colic (Walandouw, loc. cit.: Webb, loc. cit.).

The plant is considered diuretic, stomachic and anthelmintic, and is given for fistula, pustules, tumours and stomach and intestinal complaints. In Malaya, it is used for diarrhoea and in Celebes, for measles. The spikes are applied as poultices for gathered nails. Traces of hydrocyanic acid are reported to be present in roots, stems and nutlets [*J. sci. Res. Indonesia*, 1952, **1** (suppl.), 18: Mhaskar & Caius, *Indian med. Res. Mem.*, No. 19, 1931, 50: Burkill, II, 1289: Quisumbing, 1025].

The rhizome is fragrant, aromatic and astringent. A decoction of the rhizome is used as diuretic, sudorific, refrigerant, demulcent and tonic: it is given to relieve thirst in fevers and diabetes. Mixed with oil, it is used as an application for dermatitis. The rhizome is reported to yield a dark yellowish green volatile oil which has a pleasant odour and pungent taste and used for the same purposes as the decoction (Crevost & Petelot, *Bull. econ. Indoch.*, 1934, **37**, 1031; Quisumbing, 117: Nadkarni, I, 719: Kirt. & Basu, IV, 2633-34: Dymock, Warden & Hooper, III, 556–57).

**K. squamulata** Vahl=*Cyperus metzii* (Hochst.) Mattf. & Kukenthal

Fl. Br. Ind., VI, 589.

A densely tufted annual, up to 1 ft. high, with fibrous roots and leaves often longer or as long as the stem, found in the Himalayas from Kashmir to Kumaon at altitude of 5,000–6,000 ft., and in western ghats, Konkan and Kanara.

Analysis of *K. squamulata* from Jammu gave the following values (dry basis): protein, 12.85: ether extr., 2.18: mineral matter, 17.26: crude fibre, 28.84: carbohydrates, 36.35: calcium (CaO), 1.60: and phosphorus ($P_2O_5$), 0.93%. The plant is eaten by cattle (Chopra *et al.*, *Indian J. agric. Sci.*, 1956, **26**, 456).

The rhizome of the plant is similar to that of *K. erecta* Schum. & Thonn. of tropical West Africa in fragrance and aroma. It is somewhat bitter in taste. It retains its fragrance for a long time under dry conditions and is often used as a fumigant: it is sometimes chewed. The juice of the rhizome may be used for flavouring foods and medicines (Dalziel, 518).

*K. triceps* Rottb.—*Cyperus triceps* (Rottb.) Endl. is a small tufted herb, up to 12 in. high with a short rhizome and linear leaves, one half or nearly as long as the stem, found in Kumaon at altitudes of 5,000–6,000 ft. and from the upper Gangetic plain to West Bengal, Sundarbans and Deccan Peninsula. The plant has the same vernacular names as *K. monocephala* and is reported to possess properties similar to those of *K. monocephala* and *K. erecta*.

# INDEX

## (Names in Indian Languages, Regional and Trade Names and Common English Names)

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